


Exhibit 2

<p>US7187706</p> <p>1. An improvement method to a frequency division duplex (FDD) distributed-network, spread-spectrum system comprising the steps of:</p>	<p>Laird Connectivity's Sentries™ RG191+LTE Series ("The accused product")</p> <p>A system, spread-spectrum system, utilized by the accused product practices an improvement method to a frequency division duplex (FDD) distributed-network (e.g., a network comprising the accused product with 802.11b/g/n capability, another product/device to which the accused product can communicate via 802.11b/g/n communication, and several base stations).</p> <p>The accused product has LTE-FDD and 802.11b/g/n capabilities.</p> <div data-bbox="661 597 1875 1063">  </div> <p>https://www.lairdconnect.com/documentation/product-brief-sentries-rg191lte</p>
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- **LTE CAT 1 M.2 card** – 3GPP Release 11, Bands B2/4/5/12/13 supported – North America Region
- **Full Linux operating system** – Kernel v4.x running on Atmel A5 Core @ 536 MHz
- **Multiple interfaces** such as LTE CAT 1, LoRaWAN, Wi-Fi 802.11a/b/g/n and Ethernet
- **8-Channel LoRaWAN support** with up to +27 dBm max TX power
- **Comprehensive Certifications** for FCC, IC & PTCRB and co-located radio certification
- **Industrial temperature range** (-30° to +70° C)
- **Advanced deployment tools** including intuitive web-based configuration and integrated presets for multiple external LoRa Network Server vendors
- **Enterprise-grade security** built on our years of experience in wireless
- **Industry-leading support** works directly with our engineers to help deploy your design

<https://www.lairdconnect.com/documentation/product-brief-sentrius-rg191lte>

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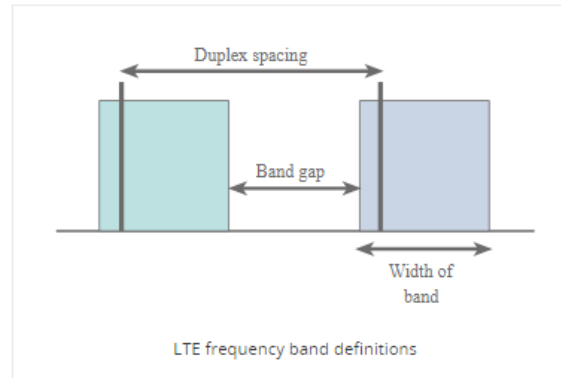
As shown below, the accused product works on LTE frequency band number 2,4,5,12,13 among others. These band numbers correspond to LTE FDD as outlined below.

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FDD LTE frequency band allocations

There is a large number of allocations or radio spectrum that has been reserved for FDD, frequency division duplex, LTE use.



<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/frequency-bands-channels-spectrum.php>

FDD LTE BANDS & FREQUENCIES					
LTE BAND NUMBER	UPLINK (MHZ)	DOWNLINK (MHZ)	WIDTH OF BAND (MHZ)	DUPLEX SPACING (MHZ)	BAND GAP (MHZ)
1	1920 - 1980	2110 - 2170	60	190	130
2	1850 - 1910	1930 - 1990	60	80	20
3	1710 - 1785	1805 - 1880	75	95	20
4	1710 - 1755	2110 - 2155	45	400	355
5	824 - 849	869 - 894	25	45	20
6	830 - 840	875 - 885	10	35	25
7	2500 - 2570	2620 - 2690	70	120	50
8	880 - 915	925 - 960	35	45	10
9	1749.9 - 1784.9	1844.9 - 1879.9	35	95	60
10	1710 - 1770	2110 - 2170	60	400	340
11	1427.9 - 1452.9	1475.9 - 1500.9	20	48	28
12	698 - 716	728 - 746	18	30	12
13	777 - 787	746 - 756	10	-31	41
14	788 - 798	758 - 768	10	-30	40
15	1900 - 1920	2600 - 2620	20	700	680
16	2010 - 2025	2585 - 2600	15	575	560
17	704 - 716	734 - 746	12	30	18
18	815 - 830	860 - 875	15	45	30
19	830 - 845	875 - 890	15	45	30
20	832 - 862	791 - 821	30	-41	71
21	1447.9 - 1462.9	1495.5 - 1510.9	15	48	33

<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/frequency-bands-channels-spectrum.php>

OFDM forms the basic signal format used within 4G LTE. OFDM, Orthogonal Frequency Division Multiplex is the basic format used and this is modified to provide the multiple access scheme: OFDMA, orthogonal frequency division multiple access in the downlink and SC-FDMA, single channel orthogonal frequency division multiple access in the uplink.

Using multiple carriers, each carrying a low data rate, OFDM is ideal for high speed data transmission because it provides resilience against narrow band fading that occurs as a result of reflections and the general propagation properties at these frequencies.

Within the basic LTE OFDM signal format a variety of modulation formats are used including PSK and QAM. Higher order modulation is used to achieve the higher data rates: the modulation order being determined by the signal quality.

LTE modulation & OFDM basics

The use of OFDM is a natural choice for LTE. While the basic concepts of OFDM are used, it has naturally been tailored to meet the exact requirements for LTE. However its use of multiple carrier each carrying a low data rate remains the same.

<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/ofdm-ofdma-scdma-modulation.php>

The Evolved Packet System (EPS) is purely IP based. Both real time services and datacom services will be carried by the IP protocol. The IP address is allocated when the mobile is switched on and released when switched off.

The new access solution, LTE, is based on OFDMA (Orthogonal Frequency Division Multiple Access) and in combination with higher order modulation (up to 64QAM), large bandwidths (up to 20 MHz) and spatial multiplexing in the downlink (up to 4x4) high data rates can be achieved. The highest theoretical peak data rate on the transport channel is 75 Mbps in the uplink, and in the downlink, using spatial multiplexing, the rate can be as high as 300 Mbps.

The LTE access network is simply a network of base stations, evolved NodeB (eNB), generating a flat architecture (figure 2). There is no centralized intelligent controller, and the eNBs are normally inter-connected via the X2-interface and towards the core network by the S1-interface (figure 2). The reason for distributing the intelligence amongst the base-stations in LTE is to speed up the connection set-up and reduce the time required for a handover. For an end-user the connection set-up time for a real time data session is in many cases crucial, especially in on-line gaming. The time for a handover is essential for real-time services where end-users tend to end calls if the handover takes too long.

<https://www.3gpp.org/technologies/keywords-acronyms/98-lte>

Since the subcarriers that carry data are transmitted at a low rate, with higher symbol time, OFDM is more resilient to multipath effects. Therefore, it is more suitable for wide-area non-line of sight wireless access technology.

Also, using overlapping orthogonal subcarriers without guard bands makes it more efficient than the FDM scheme in terms of bits per Hertz. OFDM is a spread-spectrum technology in which energy generated at a particular bandwidth is spread across a wider bandwidth making it more resilient to interference and “jamming”.

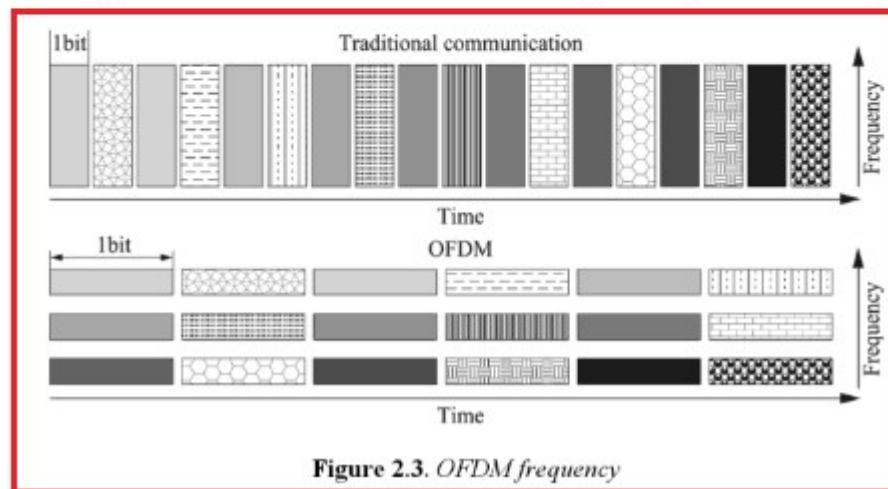


Figure 2.3. *OFDM frequency*

Source: "LTE Standards" By Jean-Gabriel Rémy, Charlotte Letamendia
<https://onlinelibrary.wiley.com/doi/book/10.1002/9781119043508>

To achieve high radio spectral efficiency as well as enable efficient scheduling in both time and frequency domain, a multicarrier approach for multiple access was chosen by 3GPP. For the downlink, OFDMA (Orthogonal Frequency Division Multiple Access) was selected and for the uplink SC-FDMA (Single Carrier - Frequency Division Multiple Access) also known as DFT (Discrete Fourier Transform) spread OFDMA (figure 3).

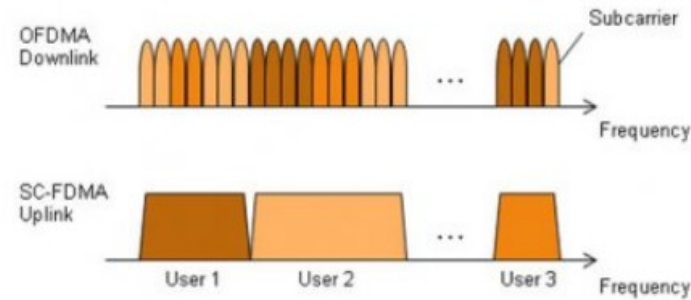


Figure 3 OFDMA and SC-FDMA

OFDM is a multicarrier technology subdividing the available bandwidth into a multitude of mutual orthogonal narrowband subcarriers. In OFDMA these subcarriers can be shared between multiple users. The OFDMA solution leads to high Peak-to-Average Power Ratio (PAPR) requiring expensive power amplifiers with high requirements on linearity, increasing the power consumption for the sender. This is no problem in the eNB, but would lead to very expensive handsets. Hence a different solution was selected for the UL. As illustrated in figure 3, the SC-FDMA solution generates a signal with single carrier characteristics, hence with a low PAPR.

<https://www.3gpp.org/technologies/keywords-acronyms/98-lte>

If we then examine the Fourier transform of our functions given in equation (8.6), we obtain a sinc function of pseudo-period T_p , which means that in the frequency domain subcarriers are spaced exactly such that the peak of the next one corresponds to the previous one's first zero – see figure 8.3.

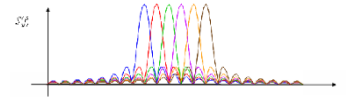


Figure 8.3: OFDM subcarrier spacing.

The overall envelope looks a bit like a spread spectrum signal, and may be tapered further to reduce out of band spectral power density.

<http://morse.colorado.edu/~tlen5510/text/classwebch8.html>

To enable possible deployment around the world, supporting as many regulatory requirements as possible, LTE is developed for a number of frequency bands – E-UTRA operating bands- currently ranging from 700 MHz up to 2.7GHz. The available bandwidths are also flexible starting with 1.4 MHz up to 20 MHz. LTE is developed to support both the time division duplex technology (TDD) as well as frequency division duplex (FDD). In R8 there are 15 bands specified for FDD and eight bands for TTD. In R9 four bands were added for FDD. Also added in R9 were for example Multimedia Broadcast Multicast Service (MBMS), and Home eNB (HeNB), see figure 4. MBMS is used to provide broadcast information to all users, for example advertisement, and multicast to a closed group subscribing to a specific service, e.g. streaming TV. HeNBs are introduced mainly to provide coverage indoors, in homes or offices. The HeNB is a low power eNB that will be used in small cells – femto cells. Normally it will be owned by the customer, deployed without any network planning and connected to the operators EPC (Evolved Packet Core).

<https://www.3gpp.org/technologies/keywords-acronyms/98-lte>

LTE can utilise both FDD - frequency division duplex and TDD - time division duplex, often referred to as TD-LTE.

Both forms of duplex, FDD and TDD have their advantages and the areas where their deployment is advantageous.

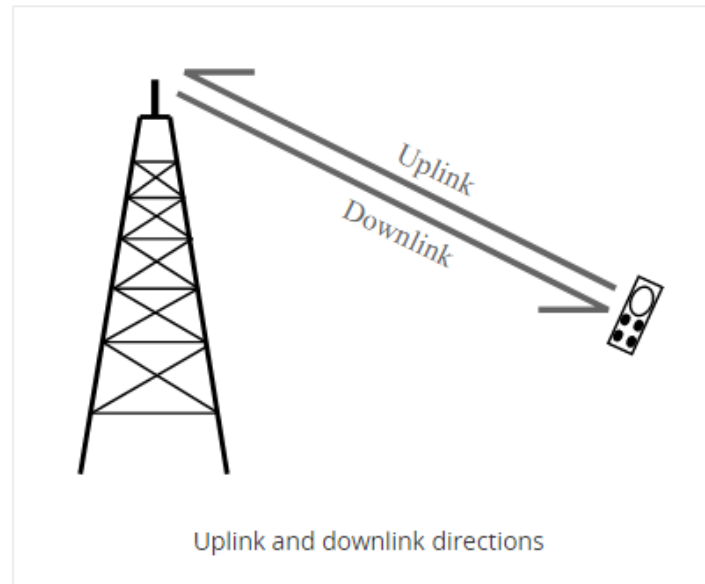
For most normal LTE deployments the frequency division duplex, FDD is used, and paired spectrum with equal bandwidth in up and downlinks is utilised.

LTE FDD using the paired spectrum was considered to be the migration path for the UMTS 3G services which typically utilised paired spectrum.

However there was considerable development placed on the time division duplex form of LTE: TDD LTE or TD-LTE which was seen as the upgrade path for TD-SCDMA that was developed and introduced by the Chinese as a 3G technology.

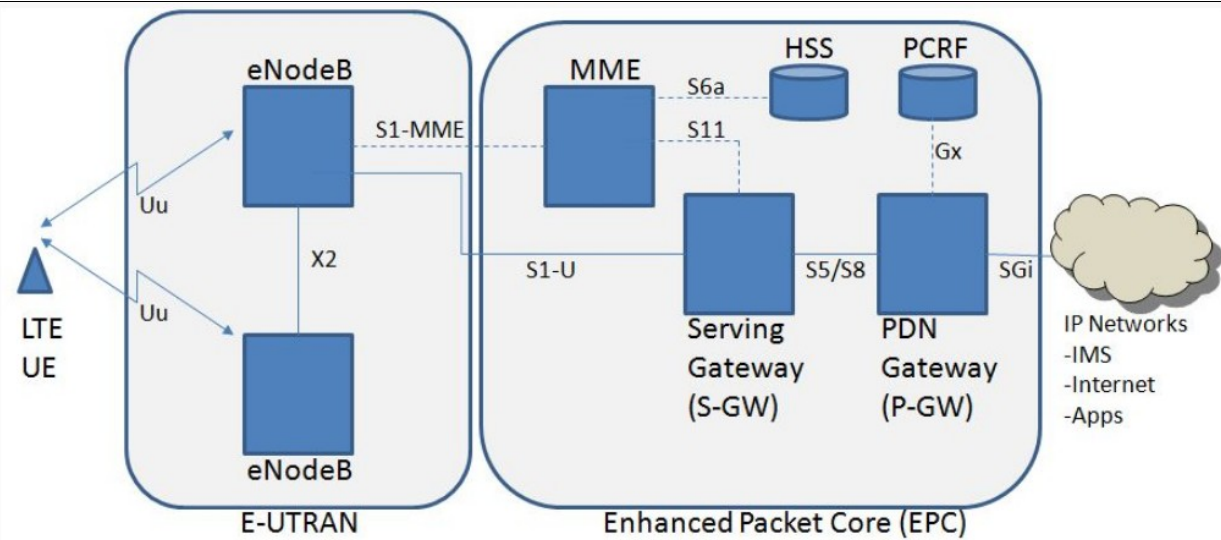
<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/tdd-fdd-td-lte-duplex-schemes.php>

- **Uplink:** the transmission from the UE or user equipment to the eNodeB or base station.
- **Downlink** the transmission from the eNodeB or base station to the UE or user equipment.

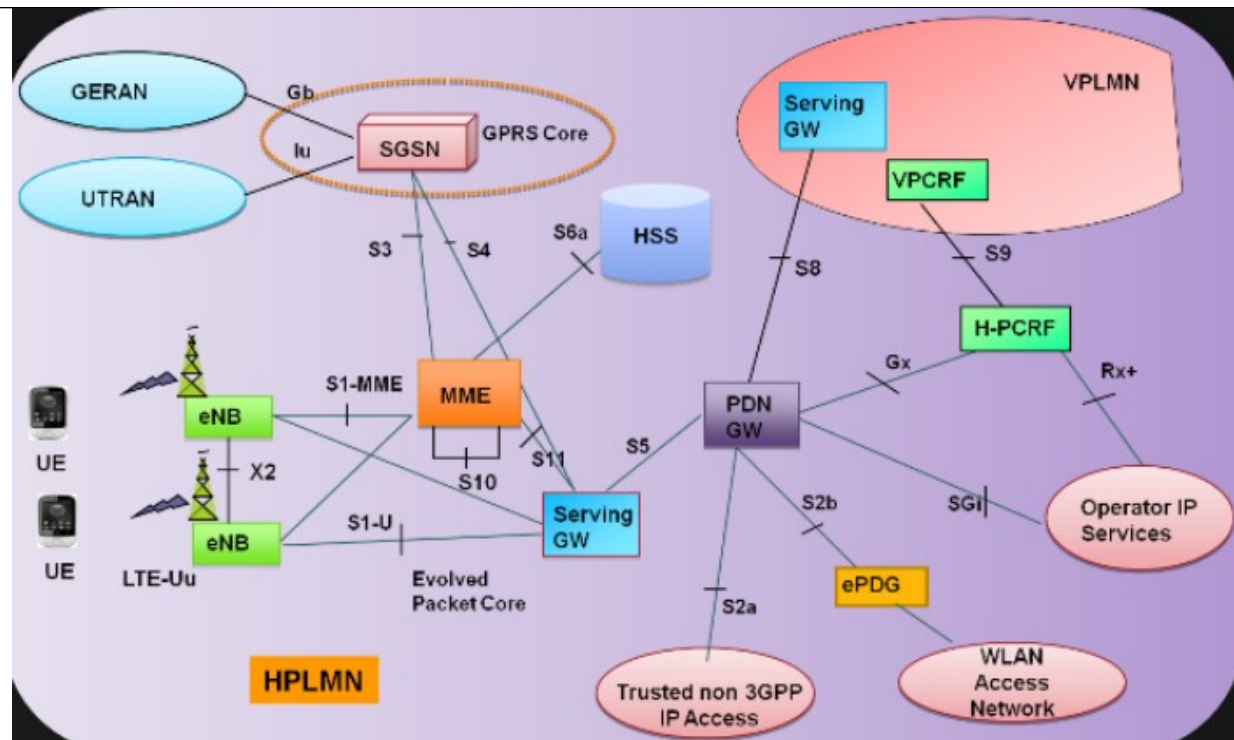


In order to be able to be able to transmit in both directions, a user equipment or base station must have a duplex scheme. There are two forms of duplex that are commonly used, namely FDD, frequency division duplex and TDD time division duplex..

<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/tdd-fdd-td-lte-duplex-schemes.php>



<https://www.rcrwireless.com/20140509/evolved-packet-core-epc/lte-network-diagram#prettyPhoto/5/>



<http://hershenq.blogspot.com/2012/03/architecture-of-lte-network-and-working.html>

transmitting, using radio waves, from a first base station (BS), located in, and part of, the FDD distributed network, a first BS-packet signal at a first frequency;
receiving at a remote station (RS) the first BS-

The system utilized by the accused product practices transmitting, using radio waves, from a first base station (BS) (e.g., a serving cell for a user equipment), located in, and part of, the FDD distributed network, a first BS-packet signal (e.g., a reference signal) at a first frequency (e.g., a first frequency) and receiving at a remote station (RS) (e.g., the accused product) the first BS-packet signal (e.g., a reference signal), thereby obtaining a first RS-received signal (e.g., a demodulated signal from a first reference signal received from the serving cell to determine RSRP value for inter-frequency cell reselection).

packet signal, thereby obtaining a first RS-received signal;

4.2.3 E-UTRAN FDD - FDD cell re-selection inter frequency case

4.2.3.1 Test purpose

To verify that when the neighbour cell operates on a different carrier frequency, compared to the current cell the UE is able to search and measure cells to meet the inter-frequency cell re-selection requirements.

4.2.3.2 Test applicability

This test applies to all types of E-UTRA FDD UE release 8 and forward.

4.2.3.3 Minimum conformance requirements

The cell re-selection delay shall be less than $T_{\text{evaluate,E-UTRAN_Inter}} + T_{\text{SI-EUTRA}}$ in RRC_IDLE state.

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is greater than $S_{\text{nonintrasearch}}$ then the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in TS 36.133 [4] clause 4.2.2 as $T_{\text{higher_priority_search}} = (60 * N_{\text{layers}})$ seconds, where the parameter N_{layers} is the total number of configured higher priority E-UTRA carrier frequencies.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is less than or equal to $S_{\text{nonintrasearch}}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible re-selection. In this scenario, the minimum rate at which the UE is required to search for and measure higher priority layers shall be the same as that defined below for lower or equal priority inter-frequency layers.

The UE shall be able to evaluate whether a newly detectable lower or equal priority inter-frequency cell meets the re-selection criteria defined in TS 36.304 [6] within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ (as defined in table 4.2.2.4-1 of TS 36.133 [4] clause 4.2.2.4) if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving

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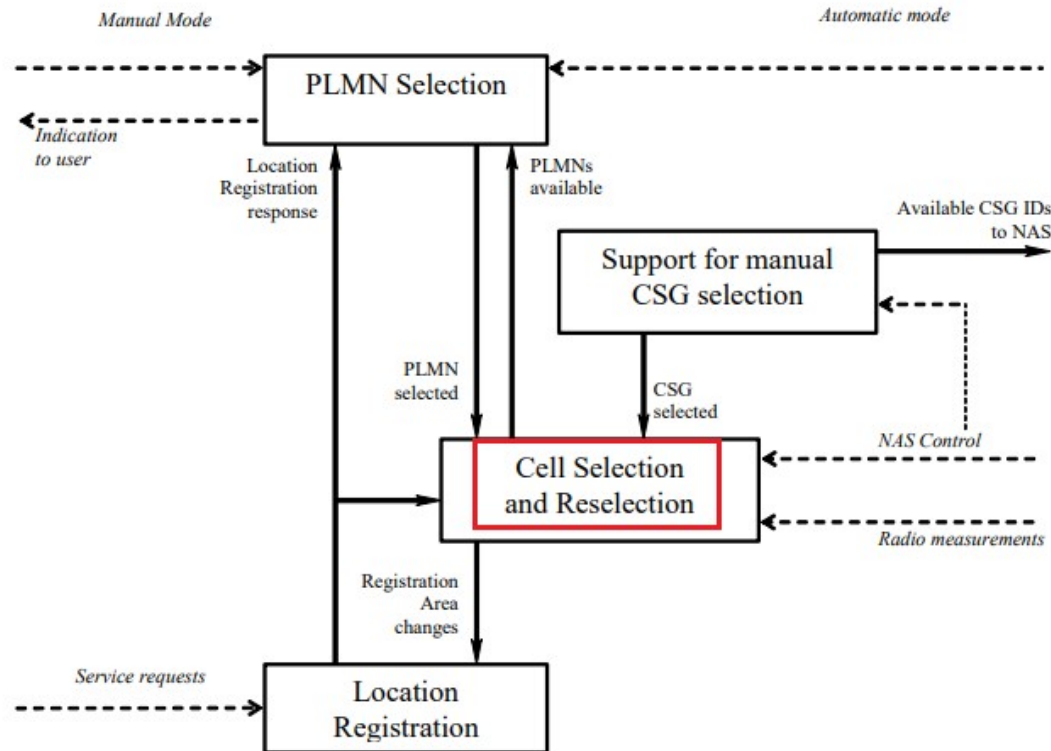


Figure 4.1-1: Overall Idle Mode process

When a UE is switched on, a public land mobile network (PLMN) is selected by NAS. For the selected PLMN, associated RAT(s) may be set [5]. The NAS shall provide a list of equivalent PLMNs, if available, that the AS shall use for cell selection and cell reselection.

With the cell selection, the UE searches for a suitable cell of the selected PLMN and chooses that cell to provide available services, further the UE shall tune to its control channel. This choosing is known as "camping on the cell".

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

	<p>The UE shall, if necessary, then register its presence, by means of a NAS registration procedure, in the tracking area of the chosen cell and as outcome of a successful Location Registration the selected PLMN becomes the registered PLMN [5].</p> <p><u>If the UE finds a more suitable cell, according to the cell reselection criteria, it reselects onto that cell and camps on it. If the new cell does not belong to at least one tracking area to which the UE is registered, location registration is performed.</u></p> <p>If necessary, the UE shall search for higher priority PLMNs at regular time intervals as described in [4] and search for a suitable cell if another PLMN has been selected by NAS.</p> <p>Search of available CSGs may be triggered by NAS to support manual CSG selection within the registered PLMN.</p> <p>If the UE loses coverage of the registered PLMN, either a new PLMN is selected automatically (automatic mode), or an indication of which PLMNs are available is given to the user, so that a manual selection can be made (manual mode).</p> <p>Registration is not performed by UEs only capable of services that need no registration.</p> <p>https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf</p>
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	<div>Cell Selection</div>	<p>Control cell selection for example by indicating RAT(s) associated with the selected PLMN to be used initially in the search of a cell in the cell selection. NAS is also maintaining lists of forbidden registration areas and a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) and provide these lists to AS.</p>	<p>Perform measurements needed to support cell selection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Search for a suitable cell. The cells broadcast one or more 'PLMN identity' in the system information. Respond to NAS whether such cell is found or not.</p> <p>If associated RATs is (are) set for the PLMN, perform the search in this (these) RAT(s) and other RATs for that PLMN as specified in [5].</p> <p>If such a cell is found, the cell is selected to camp on.</p>
	<div>Cell Reselection</div>	<p>Control cell reselection by for example, maintaining lists of forbidden registration areas.</p> <p>Maintain a list of equivalent PLMN identities and provide the list to AS.</p> <p>Maintain a list of forbidden registration areas and provide the list to AS.</p> <p>Maintain a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) to camp and provide the list to AS.</p>	<div> <p>Perform measurements needed to support cell reselection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Change cell if a more suitable cell is found.</p> </div>

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

suitable cell:

A "suitable cell" is a cell on which the UE may camp on to obtain normal service. Such a cell shall fulfil all the following requirements.

- The cell is part of either:
 - the selected PLMN, or:
 - the registered PLMN, or:
 - a PLMN of the Equivalent PLMN list
- For a CSG cell, the CSG ID broadcast by the cell is present in the allowed CSG list associated with the PLMN for which the above condition is satisfied;

According to the latest information provided by NAS:

- The cell is not barred, see subclause 5.3.1;
- The cell is part of at least one TA that is not part of the list of "forbidden tracking areas for roaming" [4], which belongs to a PLMN that fulfils the first bullet above;
- The cell selection criteria are fulfilled, see subclause 5.2.3.2;

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

5.2 Cell selection and reselection

5.2.1 Introduction

UE shall perform measurements for cell selection and reselection purposes as specified in [10].

The NAS can control the RAT(s) in which the cell selection should be performed, for instance by indicating RAT(s) associated with the selected PLMN, and by maintaining a list of forbidden registration area(s) and a list of equivalent PLMNs. The UE shall select a suitable cell based on idle mode measurements and cell selection criteria.

In order to speed up the cell selection process, stored information for several RATs may be available in the UE.

When camped on a cell, the UE shall regularly search for a better cell according to the cell reselection criteria. If a better cell is found, that cell is selected. The change of cell may imply a change of RAT. Details on performance requirements for cell reselection can be found in [10].

The NAS is informed if the cell selection and reselection results in changes in the received system information relevant for NAS.

For normal service, the UE shall camp on a suitable cell, tune to that cell's control channel(s) so that the UE can:

- Receive system information from the PLMN; and
 - receive registration area information from the PLMN, e.g., tracking area information; and
 - receive other AS and NAS Information; and
- if registered:
 - receive paging and notification messages from the PLMN; and
 - initiate transfer to connected mode.

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

5.2.4.5 E-UTRAN Inter-frequency and inter-RAT Cell Reselection criteria

Criteria 1: the $S_{\text{nonServingCell},x}$ of a cell on evaluated frequency is greater than $\text{Thresh}_{x, \text{high}}$ during a time interval $\text{Treselection}_{\text{RAT}}$;

Cell reselection to a cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- A cell of a higher priority E-UTRAN frequency or inter-RAT frequency fulfils criteria 1; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

Cell reselection to a cell on an equal priority E-UTRAN frequency shall be based on ranking for Intra-frequency cell reselection as defined in sub-clause 5.2.4.6.

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- No cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency fulfills the criteria 1; and
- No cell on serving frequency or on an equal priority E-UTRAN frequency fulfills the criteria in 5.2.4.6; and
- $S_{\text{ServingCell}} < \text{Thresh}_{\text{serving, low}}$ and the $S_{\text{nonServingCell},x}$ of a cell of a lower priority E-UTRAN frequency or inter-RAT frequency is greater than $\text{Thresh}_{x, \text{low}}$ during a time interval $\text{Treselection}_{\text{RAT}}$; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

For GERAN, UTRAN, and E-UTRAN, $S_{\text{nonServingCell},x}$ is the S_{rxlev} -value of an evaluated cell. For UTRAN FDD, S_{qual} is higher than 0, as defined in [8]. For cdma2000 RATs, $S_{\text{nonServingCell},x}$ is equal to $-\text{FLOOR}(-2 \times 10 \times \log_{10} E_c/I_o)$ in units of 0.5 dB, as defined in [18], with E_c/I_o referring to the value measured from the evaluated cell.

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5.2.4 Cell Reselection evaluation process

5.2.4.1 Reselection priorities handling

Absolute priorities of different E-UTRAN frequencies or inter-RAT frequencies may be provided to the UE in the system information, in the *RRCConnectionRelease* message, or by inheriting from another RAT at inter-RAT cell (re)selection. In the case of system information, an E-UTRAN frequency or inter-RAT frequency may be listed without providing a priority (i.e. the field *cellReselectionPriority* is absent for that frequency). If priorities are provided in dedicated signalling, the UE shall ignore all the priorities provided in system information. If UE is in *camped on any cell* state, UE shall only apply the priorities provided by system information from current cell, and the UE preserves priorities provided by dedicated signalling unless specified otherwise. When the UE in *camped normally* state, has only dedicated priorities other than for the current frequency, the UE shall consider the current frequency to be the lowest priority frequency (i.e. lower than the eight network configured values). While the UE is camped on a suitable CSG cell, the UE shall always consider the current frequency to be the highest priority frequency (i.e. higher than the eight network configured values), irrespective of any other priority value allocated to this frequency. The UE shall delete priorities provided by dedicated signalling when:

- the UE enters RRC_CONNECTED state; or
- the optional validity time of dedicated priorities (T320) expires; or
- a PLMN selection is performed on request by NAS [5].

NOTE: Equal priorities between RATs are not supported.

The UE shall only perform cell reselection evaluation for E-UTRAN frequencies and inter-RAT frequencies that are given in system information and for which the UE has a priority provided.

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

5.2.4.2 Measurement rules for cell re-selection

When evaluating for reselection purposes cell selection criterion or $S_{\text{ServingCell},x}$, the UE shall use parameters provided by the serving cell.

Following rules are used by the UE to limit needed measurements:

- If $S_{\text{intrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{intrasearch}}$, UE may choose to not perform intra-frequency measurements.
- If $S_{\text{ServingCell}} \leq S_{\text{intrasearch}}$, or $S_{\text{intrasearch}}$ is not sent in the serving cell UE shall perform intra-frequency measurements.
- The UE shall apply the following rules for E-UTRAN inter-frequencies and inter-RAT frequencies which are indicated in system information and for which the UE has priority provided as defined in 5.2.4.1:
 - For an E-UTRAN inter-frequency or inter-RAT frequency with a reselection priority higher than the reselection priority of the current E-UTRA frequency the UE shall perform measurements of higher priority E-UTRAN inter-frequency or inter-RAT frequencies according to [10].

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- For an E-UTRAN inter-frequency with an equal or lower reselection priority than the reselection priority of the current E-UTRA frequency and for inter-RAT frequency with lower reselection priority than the reselection priority of the current E-UTRAN frequency:
 - If $S_{\text{nonintrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{nonintrasearch}}$ UE may choose not to perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority.
 - If $S_{\text{ServingCell}} \leq S_{\text{nonintrasearch}}$ or $S_{\text{nonintrasearch}}$ is not sent in the serving cell the UE shall perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority according to [10].

Where $S_{\text{ServingCell}}$ is the S_{rxlev} -value of the serving cell.

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The cell selection criterion S is fulfilled when:

$$S_{rxlev} > 0$$

Where:

$$S_{rxlev} = Q_{rxlevmeas} - (Q_{rxlevmin} + Q_{rxlevminoffset}) - P_{compensation}$$

Where:

the signalled value $Q_{rxlevminOffset}$ is only applied when a cell is evaluated for cell selection as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]. During this periodic search for higher priority PLMN the UE may check the S criteria of a cell using parameter values stored from a different cell of this higher priority PLMN.

S_{rxlev}	Cell Selection RX level value (dB)
$Q_{rxlevmeas}$	Measured cell RX level value (RSRP).
$Q_{rxlevmin}$	Minimum required RX level in the cell (dBm)
$Q_{rxlevminoffset}$	Offset to the signalled $Q_{rxlevmin}$ taken into account in the S_{rxlev} evaluation as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]
$P_{compensation}$	$\max(P_{EMAX} - P_{PowerClass}, 0)$ (dB)
P_{EMAX}	Maximum TX power level an UE may use when transmitting on the uplink in the cell (dBm) defined as P_{EMAX} in [TS 36.101]
$P_{PowerClass}$	Maximum RF output power of the UE (dBm) according to the UE power class as defined in [TS 36.101]

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4.2.2.4 Measurements of inter-frequency E-UTRAN cells

[Editor's note: The RAN2 measurement rules for inter frequency are still to be clarified . It is assumed that the following parameter is defined : $\text{Thresh}_{\text{serv_high}}$: Threshold for the LTE serving cell when the UE initiates measurements, or increases the measurement rate (in the case of high to low priority reselection) on a different E-UTRA frequency layer. This section should be reviewed and updated once more detailed measurement rules are defined by RAN2.]

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the RSRP of the E-UTRA serving cell (or other cells on the same frequency layer) is greater than $\text{Thresh}_{\text{serv_high}}$ then

- the UE may not search for, or measure inter-frequency or inter-RAT layers of equal or lower priority.

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- the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in section 4.2.2. *Editors note: The measurement of cells that are detected in this search is still to be described.*

If the RSRP of the E-UTRA serving cell is less than or equal to $\text{Thresh}_{\text{serv_high},x}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible reselection. In this scenario, the minimum rate at which the UE is required to search for and measure such layers is not reduced.

The UE shall be able to evaluate the need for reselection to a newly detectable inter-frequency cell within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving cells assuming that $T_{\text{reselection}} = 0$. The parameter K_{carrier} is the number of E-UTRA inter-frequency carriers indicated by the serving cell. It shall be possible to evaluate the need for reselection to cells which have:

- $\text{RSRP} \geq -\text{TBD dBm}$ and $\text{Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) \geq [-3] \text{ dB}$.
- $\text{SCH Ior} > -\text{TBD dBm}$ and $\text{SCH Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) > [-3] \text{ dB}$. The UE shall measure RSRP at least every $K_{\text{carrier}} * T_{\text{measure,EUTRAN_Inter}}$ DRX cycle (see table 4.2.2.3-1) for identified inter-frequency cells. If the UE detects on a E-UTRA carrier a cell whose physical identity is indicated as not allowed for that carrier in the measurement control system information of the serving cell, the UE is not required to perform measurements on that cell.

The UE shall filter RSRP measurements of each measured inter-frequency cell using at least [2] measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by at least $[T_{\text{measure,EUTRAN_Inter}}/2]$.

The UE shall not consider a E-UTRA neighbour cell in cell reselection, if it is indicated as not allowed in the measurement control system information of the serving cell.

The filtering shall be such that the UE shall be capable of evaluating that the inter-frequency cell has met reselection criterion defined TS 36.304 within $T_{\text{evaluateFDD,Inter}}$ as specified in table 4.2.2.4-1.

Table 4.2.2.4-1 : $T_{\text{detect,EUTRAN_Inter}}$, $T_{\text{measure,EUTRAN_Inter}}$ and $T_{\text{evaluateFDD,Inter}}$

DRX cycle length [s]	$T_{\text{detect,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{measure,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{evaluateFDD,Inter}}$ [s] (number of DRX cycles)
0.32	[11.52 (36)]	[1.28 (4)]	[5.12 (16)]
0.64	[17.92 (28)]	[1.28 (2)]	[5.12 (8)]
1.28	[32(25)]	[1.28 (1)]	[6.4 (5)]
2.56	[55.88 (23)]	[2.56 (1)]	[7.68 (3)]

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<p>transmitting, using radio waves, from a second base station a second BS-packet signal at a second frequency, with the second frequency different from the first frequency; receiving at said remote station the second BS-packet signal at the second frequency, thereby obtaining a second RS-received signal;</p>	<p>The system utilized by the accused product practices transmitting, using radio waves, from a second base station (e.g., a cell other than the serving cell of a user equipment) a second BS-packet signal (e.g., a reference signal from a cell other than the serving cell) at a second frequency (e.g., inter-frequency cell reselection, a cell operates at different carrier frequency, i.e., reference signal frequency, than the serving cell of a user equipment), with the second frequency different from the first frequency and receiving at said remote station (e.g., the accused product) the second BS-packet signal (e.g., a reference signal from a cell other than the serving cell) at the second frequency, thereby obtaining a second RS-received signal (e.g., a demodulated signal from a reference signal received from a cell other than the serving cell to determine RSRP value for inter-frequency cell reselection).</p>
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4.2.3 E-UTRAN FDD - FDD cell re-selection inter frequency case

4.2.3.1 Test purpose

To verify that when the neighbour cell operates on a different carrier frequency, compared to the current cell the UE is able to search and measure cells to meet the inter-frequency cell re-selection requirements.

4.2.3.2 Test applicability

This test applies to all types of E-UTRA FDD UE release 8 and forward.

4.2.3.3 Minimum conformance requirements

The cell re-selection delay shall be less than $T_{\text{evaluate,E-UTRAN_Inter}} + T_{\text{SI-EUTRA}}$ in RRC_IDLE state.

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is greater than $S_{\text{nonintrasearch}}$ then the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher priority search}}$ where $T_{\text{higher priority search}}$ is described in TS 36.133 [4] clause 4.2.2 as $T_{\text{higher priority search}} = (60 * N_{\text{layers}})$ seconds, where the parameter N_{layers} is the total number of configured higher priority E-UTRA carrier frequencies.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is less than or equal to $S_{\text{nonintrasearch}}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible re-selection. In this scenario, the minimum rate at which the UE is required to search for and measure higher priority layers shall be the same as that defined below for lower or equal priority inter-frequency layers.

The UE shall be able to evaluate whether a newly detectable lower or equal priority inter-frequency cell meets the re-selection criteria defined in TS 36.304 [6] within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ (as defined in table 4.2.2.4-1 of TS 36.133 [4] clause 4.2.2.4) if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving

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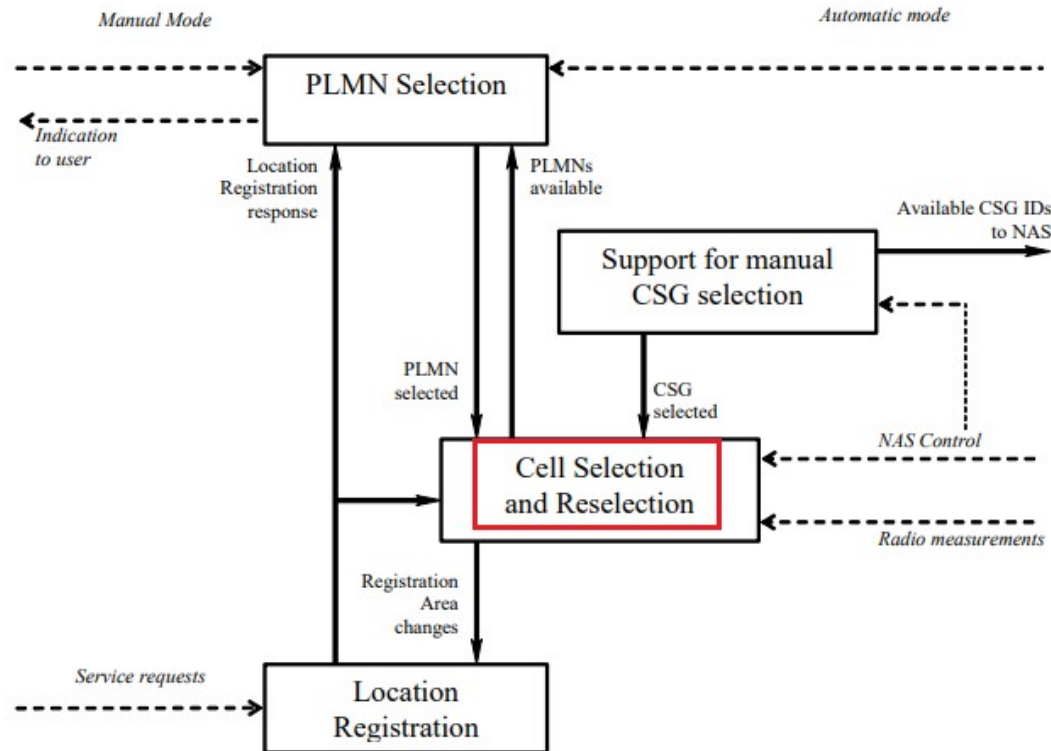


Figure 4.1-1: Overall Idle Mode process

When a UE is switched on, a public land mobile network (PLMN) is selected by NAS. For the selected PLMN, associated RAT(s) may be set [5]. The NAS shall provide a list of equivalent PLMNs, if available, that the AS shall use for cell selection and cell reselection.

With the cell selection, the UE searches for a suitable cell of the selected PLMN and chooses that cell to provide available services, further the UE shall tune to its control channel. This choosing is known as "camping on the cell".

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	<p>The UE shall, if necessary, then register its presence, by means of a NAS registration procedure, in the tracking area of the chosen cell and as outcome of a successful Location Registration the selected PLMN becomes the registered PLMN [5].</p> <p><u>If the UE finds a more suitable cell, according to the cell reselection criteria, it reselects onto that cell and camps on it. If the new cell does not belong to at least one tracking area to which the UE is registered, location registration is performed.</u></p> <p>If necessary, the UE shall search for higher priority PLMNs at regular time intervals as described in [4] and search for a suitable cell if another PLMN has been selected by NAS.</p> <p>Search of available CSGs may be triggered by NAS to support manual CSG selection within the registered PLMN.</p> <p>If the UE loses coverage of the registered PLMN, either a new PLMN is selected automatically (automatic mode), or an indication of which PLMNs are available is given to the user, so that a manual selection can be made (manual mode).</p> <p>Registration is not performed by UEs only capable of services that need no registration.</p> <p>https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf</p>
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	<div>Cell Selection</div>	<p>Control cell selection for example by indicating RAT(s) associated with the selected PLMN to be used initially in the search of a cell in the cell selection. NAS is also maintaining lists of forbidden registration areas and a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) and provide these lists to AS.</p>	<p>Perform measurements needed to support cell selection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Search for a suitable cell. The cells broadcast one or more 'PLMN identity' in the system information. Respond to NAS whether such cell is found or not.</p> <p>If associated RATs is (are) set for the PLMN, perform the search in this (these) RAT(s) and other RATs for that PLMN as specified in [5].</p> <p>If such a cell is found, the cell is selected to camp on.</p>
	<div>Cell Reselection</div>	<p>Control cell reselection by for example, maintaining lists of forbidden registration areas.</p> <p>Maintain a list of equivalent PLMN identities and provide the list to AS.</p> <p>Maintain a list of forbidden registration areas and provide the list to AS.</p> <p>Maintain a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) to camp and provide the list to AS.</p>	<div> <p>Perform measurements needed to support cell reselection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Change cell if a more suitable cell is found.</p> </div>

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suitable cell:

A "suitable cell" is a cell on which the UE may camp on to obtain normal service. Such a cell shall fulfil all the following requirements.

- The cell is part of either:
 - the selected PLMN, or:
 - the registered PLMN, or:
 - a PLMN of the Equivalent PLMN list
- For a CSG cell, the CSG ID broadcast by the cell is present in the allowed CSG list associated with the PLMN for which the above condition is satisfied;

According to the latest information provided by NAS:

- The cell is not barred, see subclause 5.3.1;
- The cell is part of at least one TA that is not part of the list of "forbidden tracking areas for roaming" [4], which belongs to a PLMN that fulfils the first bullet above;
- The cell selection criteria are fulfilled, see subclause 5.2.3.2;

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5.2 Cell selection and reselection

5.2.1 Introduction

UE shall perform measurements for cell selection and reselection purposes as specified in [10].

The NAS can control the RAT(s) in which the cell selection should be performed, for instance by indicating RAT(s) associated with the selected PLMN, and by maintaining a list of forbidden registration area(s) and a list of equivalent PLMNs. The UE shall select a suitable cell based on idle mode measurements and cell selection criteria.

In order to speed up the cell selection process, stored information for several RATs may be available in the UE.

When camped on a cell, the UE shall regularly search for a better cell according to the cell reselection criteria. If a better cell is found, that cell is selected. The change of cell may imply a change of RAT. Details on performance requirements for cell reselection can be found in [10].

The NAS is informed if the cell selection and reselection results in changes in the received system information relevant for NAS.

For normal service, the UE shall camp on a suitable cell, tune to that cell's control channel(s) so that the UE can:

- Receive system information from the PLMN; and
 - receive registration area information from the PLMN, e.g., tracking area information; and
 - receive other AS and NAS Information; and
- if registered:
 - receive paging and notification messages from the PLMN; and
 - initiate transfer to connected mode.

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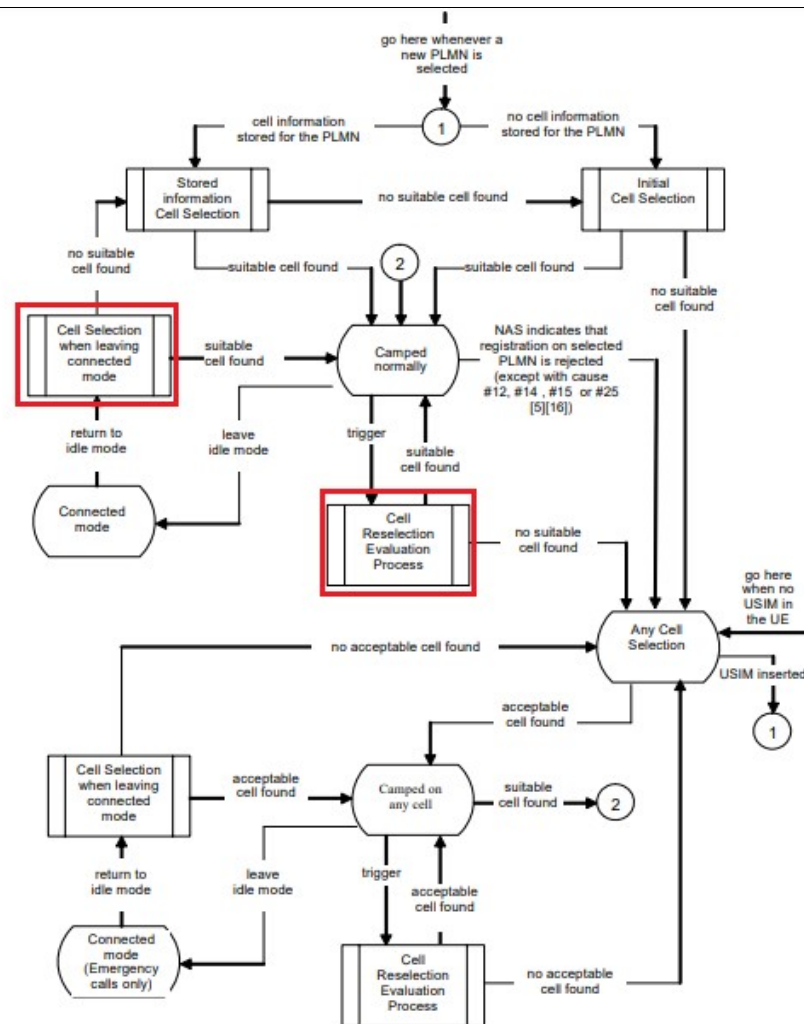


Figure 5.2.2-1: RRC_IDLE Cell Selection and Reselection

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5.2.4.5 E-UTRAN Inter-frequency and inter-RAT Cell Reselection criteria

Criteria 1: the $S_{\text{nonServingCell},x}$ of a cell on evaluated frequency is greater than $\text{Thresh}_{x,\text{high}}$ during a time interval $\text{Treselection}_{\text{RAT}}$;

Cell reselection to a cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- A cell of a higher priority E-UTRAN frequency or inter-RAT frequency fulfils criteria 1; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

Cell reselection to a cell on an equal priority E-UTRAN frequency shall be based on ranking for Intra-frequency cell reselection as defined in sub-clause 5.2.4.6.

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- No cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency fulfills the criteria 1; and
- No cell on serving frequency or on an equal priority E-UTRAN frequency fulfills the criteria in 5.2.4.6; and
- $S_{\text{ServingCell}} < \text{Thresh}_{\text{serving, low}}$ and the $S_{\text{nonServingCell},x}$ of a cell of a lower priority E-UTRAN frequency or inter-RAT frequency is greater than $\text{Thresh}_{x,\text{low}}$ during a time interval $\text{Treselection}_{\text{RAT}}$; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

For GERAN, UTRAN, and E-UTRAN, $S_{\text{nonServingCell},x}$ is the S_{rxlev} -value of an evaluated cell. For UTRAN FDD, S_{qual} is higher than 0, as defined in [8]. For cdma2000 RATs, $S_{\text{nonServingCell},x}$ is equal to $-\text{FLOOR}(-2 \times 10 \times \log_{10} E_c/I_o)$ in units of 0.5 dB, as defined in [18], with E_c/I_o referring to the value measured from the evaluated cell.

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5.2.4 Cell Reselection evaluation process

5.2.4.1 Reselection priorities handling

Absolute priorities of different E-UTRAN frequencies or inter-RAT frequencies may be provided to the UE in the system information, in the *RRCConnectionRelease* message, or by inheriting from another RAT at inter-RAT cell (re)selection. In the case of system information, an E-UTRAN frequency or inter-RAT frequency may be listed without providing a priority (i.e. the field *cellReselectionPriority* is absent for that frequency). If priorities are provided in dedicated signalling, the UE shall ignore all the priorities provided in system information. If UE is in *camped on any cell* state, UE shall only apply the priorities provided by system information from current cell, and the UE preserves priorities provided by dedicated signalling unless specified otherwise. When the UE in *camped normally* state, has only dedicated priorities other than for the current frequency, the UE shall consider the current frequency to be the lowest priority frequency (i.e. lower than the eight network configured values). While the UE is camped on a suitable CSG cell, the UE shall always consider the current frequency to be the highest priority frequency (i.e. higher than the eight network configured values), irrespective of any other priority value allocated to this frequency. The UE shall delete priorities provided by dedicated signalling when:

- the UE enters RRC_CONNECTED state; or
- the optional validity time of dedicated priorities (T320) expires; or
- a PLMN selection is performed on request by NAS [5].

NOTE: Equal priorities between RATs are not supported.

The UE shall only perform cell reselection evaluation for E-UTRAN frequencies and inter-RAT frequencies that are given in system information and for which the UE has a priority provided.

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5.2.4.2 Measurement rules for cell re-selection

When evaluating for reselection purposes cell selection criterion or $S_{\text{ServingCell},x}$, the UE shall use parameters provided by the serving cell.

Following rules are used by the UE to limit needed measurements:

- If $S_{\text{intrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{intrasearch}}$, UE may choose to not perform intra-frequency measurements.
- If $S_{\text{ServingCell}} \leq S_{\text{intrasearch}}$, or $S_{\text{intrasearch}}$ is not sent in the serving cell UE shall perform intra-frequency measurements.
- The UE shall apply the following rules for E-UTRAN inter-frequencies and inter-RAT frequencies which are indicated in system information and for which the UE has priority provided as defined in 5.2.4.1:
 - For an E-UTRAN inter-frequency or inter-RAT frequency with a reselection priority higher than the reselection priority of the current E-UTRA frequency the UE shall perform measurements of higher priority E-UTRAN inter-frequency or inter-RAT frequencies according to [10].

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- For an E-UTRAN inter-frequency with an equal or lower reselection priority than the reselection priority of the current E-UTRA frequency and for inter-RAT frequency with lower reselection priority than the reselection priority of the current E-UTRAN frequency:
 - If $S_{\text{nonintrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{nonintrasearch}}$ UE may choose not to perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority.
 - If $S_{\text{ServingCell}} \leq S_{\text{nonintrasearch}}$ or $S_{\text{nonintrasearch}}$ is not sent in the serving cell the UE shall perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority according to [10].

Where $S_{\text{ServingCell}}$ is the S_{rxlev} -value of the serving cell.

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The cell selection criterion S is fulfilled when:

$$S_{rxlev} > 0$$

Where:

$$S_{rxlev} = Q_{rxlevmeas} - (Q_{rxlevmin} + Q_{rxlevminoffset}) - P_{compensation}$$

Where:

the signalled value $Q_{rxlevminOffset}$ is only applied when a cell is evaluated for cell selection as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]. During this periodic search for higher priority PLMN the UE may check the S criteria of a cell using parameter values stored from a different cell of this higher priority PLMN.

S_{rxlev}	Cell Selection RX level value (dB)
$Q_{rxlevmeas}$	Measured cell RX level value (RSRP).
$Q_{rxlevmin}$	Minimum required RX level in the cell (dBm)
$Q_{rxlevminoffset}$	Offset to the signalled $Q_{rxlevmin}$ taken into account in the S_{rxlev} evaluation as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]
$P_{compensation}$	$\max(P_{EMAX} - P_{PowerClass}, 0)$ (dB)
P_{EMAX}	Maximum TX power level an UE may use when transmitting on the uplink in the cell (dBm) defined as P_{EMAX} in [TS 36.101]
$P_{PowerClass}$	Maximum RF output power of the UE (dBm) according to the UE power class as defined in [TS 36.101]

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4.2.2.4 Measurements of inter-frequency E-UTRAN cells

[Editor's note: The RAN2 measurement rules for inter frequency are still to be clarified . It is assumed that the following parameter is defined : $\text{Thresh}_{\text{-serving_high}}$: Threshold for the LTE serving cell when the UE initiates measurements, or increases the measurement rate (in the case of high to low priority reselection) on a different E-UTRA frequency layer. This section should be reviewed and updated once more detailed measurement rules are defined by RAN2.]

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the RSRP of the E-UTRA serving cell (or other cells on the same frequency layer) is greater than $\text{Thresh}_{\text{-serving_high}}$ then

- the UE may not search for, or measure inter-frequency or inter-RAT layers of equal or lower priority.

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- the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in section 4.2.2. *Editors note: The measurement of cells that are detected in this search is still to be described.*

If the RSRP of the E-UTRA serving cell is less than or equal to $\text{Thresh}_{\text{serv_high},x}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible reselection. In this scenario, the minimum rate at which the UE is required to search for and measure such layers is not reduced.

The UE shall be able to evaluate the need for reselection to a newly detectable inter-frequency cell within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving cells assuming that $T_{\text{reselection}} = 0$. The parameter K_{carrier} is the number of E-UTRA inter-frequency carriers indicated by the serving cell. It shall be possible to evaluate the need for reselection to cells which have:

- $\text{RSRP} \geq -\text{TBD dBm}$ and $\text{Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) \geq [-3] \text{ dB}$.
- $\text{SCH Ior} > -\text{TBD dBm}$ and $\text{SCH Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) > [-3] \text{ dB}$. The UE shall measure RSRP at least every $K_{\text{carrier}} * T_{\text{measure,EUTRAN_Inter}}$ DRX cycle (see table 4.2.2.3-1) for identified inter-frequency cells. If the UE detects on a E-UTRA carrier a cell whose physical identity is indicated as not allowed for that carrier in the measurement control system information of the serving cell, the UE is not required to perform measurements on that cell.

The UE shall filter RSRP measurements of each measured inter-frequency cell using at least [2] measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by at least $[T_{\text{measure,EUTRAN_Inter}}/2]$.

The UE shall not consider a E-UTRA neighbour cell in cell reselection, if it is indicated as not allowed in the measurement control system information of the serving cell.

The filtering shall be such that the UE shall be capable of evaluating that the inter-frequency cell has met reselection criterion defined TS 36.304 within $T_{\text{evaluateFDD,Inter}}$ as specified in table 4.2.2.4-1.

Table 4.2.2.4-1 : $T_{\text{detect,EUTRAN_Inter}}$, $T_{\text{measure,EUTRAN_Inter}}$ and $T_{\text{evaluateFDD,Inter}}$

DRX cycle length [s]	$T_{\text{detect,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{measure,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{evaluateFDD,Inter}}$ [s] (number of DRX cycles)
0.32	[11.52 (36)]	[1.28 (4)]	[5.12 (16)]
0.64	[17.92 (28)]	[1.28 (2)]	[5.12 (8)]
1.28	[32(25)]	[1.28 (1)]	[6.4 (5)]
2.56	[55.88 (23)]	[2.56 (1)]	[7.68 (3)]

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monitoring at said remote station a first signal metric of the first RS-received signal, and a second signal metric of the second RS-received signal; and

The accused product practices monitoring a first signal metric (e.g., a RSRP value of the reference signal of the serving cell) of the first RS-received signal (e.g., a demodulated signal from a first reference signal received from the serving cell to determine RSRP value for inter-frequency cell reselection), and a second signal metric (e.g., a RSRP value of the reference signal of the cell other than the serving cell) of the second RS-received signal (e.g., a demodulated signal from a second reference signal received from a cell other than the serving cell to determine RSRP value for inter-frequency cell reselection).

4.2.3 E-UTRAN FDD - FDD cell re-selection inter frequency case

4.2.3.1 Test purpose

To verify that when the neighbour cell operates on a different carrier frequency, compared to the current cell the UE is able to search and measure cells to meet the inter-frequency cell re-selection requirements.

4.2.3.2 Test applicability

This test applies to all types of E-UTRA FDD UE release 8 and forward.

4.2.3.3 Minimum conformance requirements

The cell re-selection delay shall be less than $T_{\text{evaluate,E-UTRAN_Inter}} + T_{\text{SI-EUTRA}}$ in RRC_IDLE state.

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is greater than $S_{\text{nonintrasearch}}$ then the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in TS 36.133 [4] clause 4.2.2 as $T_{\text{higher_priority_search}} = (60 * N_{\text{layers}})$ seconds, where the parameter N_{layers} is the total number of configured higher priority E-UTRA carrier frequencies.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is less than or equal to $S_{\text{nonintrasearch}}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible re-selection. In this scenario, the minimum rate at which the UE is required to search for and measure higher priority layers shall be the same as that defined below for lower or equal priority inter-frequency layers.

The UE shall be able to evaluate whether a newly detectable lower or equal priority inter-frequency cell meets the re-selection criteria defined in TS 36.304 [6] within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ (as defined in table 4.2.2.4-1 of TS 36.133 [4] clause 4.2.2.4) if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving

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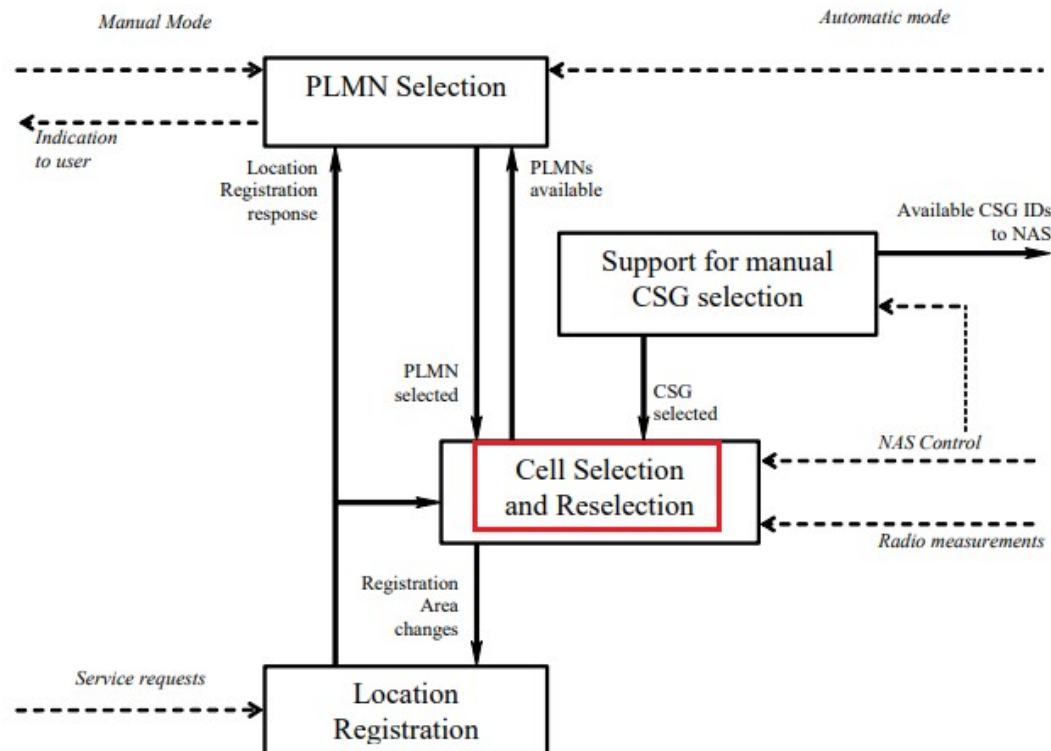


Figure 4.1-1: Overall Idle Mode process

When a UE is switched on, a public land mobile network (PLMN) is selected by NAS. For the selected PLMN, associated RAT(s) may be set [5]. The NAS shall provide a list of equivalent PLMNs, if available, that the AS shall use for cell selection and cell reselection.

With the cell selection, the UE searches for a suitable cell of the selected PLMN and chooses that cell to provide available services, further the UE shall tune to its control channel. This choosing is known as "camping on the cell".

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	<p>The UE shall, if necessary, then register its presence, by means of a NAS registration procedure, in the tracking area of the chosen cell and as outcome of a successful Location Registration the selected PLMN becomes the registered PLMN [5].</p> <p><u>If the UE finds a more suitable cell, according to the cell reselection criteria, it reselects onto that cell and camps on it. If the new cell does not belong to at least one tracking area to which the UE is registered, location registration is performed.</u></p> <p>If necessary, the UE shall search for higher priority PLMNs at regular time intervals as described in [4] and search for a suitable cell if another PLMN has been selected by NAS.</p> <p>Search of available CSGs may be triggered by NAS to support manual CSG selection within the registered PLMN.</p> <p>If the UE loses coverage of the registered PLMN, either a new PLMN is selected automatically (automatic mode), or an indication of which PLMNs are available is given to the user, so that a manual selection can be made (manual mode).</p> <p>Registration is not performed by UEs only capable of services that need no registration.</p> <p>https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf</p>
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Cell Selection	<p>Control cell selection for example by indicating RAT(s) associated with the selected PLMN to be used initially in the search of a cell in the cell selection. NAS is also maintaining lists of forbidden registration areas and a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) and provide these lists to AS.</p>	<p>Perform measurements needed to support cell selection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Search for a suitable cell. The cells broadcast one or more 'PLMN identity' in the system information. Respond to NAS whether such cell is found or not.</p> <p>If associated RATs is (are) set for the PLMN, perform the search in this (these) RAT(s) and other RATs for that PLMN as specified in [5].</p> <p>If such a cell is found, the cell is selected to camp on.</p>
Cell Reselection	<p>Control cell reselection by for example, maintaining lists of forbidden registration areas.</p> <p>Maintain a list of equivalent PLMN identities and provide the list to AS.</p> <p>Maintain a list of forbidden registration areas and provide the list to AS.</p> <p>Maintain a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) to camp and provide the list to AS.</p>	<p>Perform measurements needed to support cell reselection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Change cell if a more suitable cell is found.</p>

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suitable cell:

A "suitable cell" is a cell on which the UE may camp on to obtain normal service. Such a cell shall fulfil all the following requirements.

- The cell is part of either:
 - the selected PLMN, or:
 - the registered PLMN, or:
 - a PLMN of the Equivalent PLMN list
- For a CSG cell, the CSG ID broadcast by the cell is present in the allowed CSG list associated with the PLMN for which the above condition is satisfied;

According to the latest information provided by NAS:

- The cell is not barred, see subclause 5.3.1;
- The cell is part of at least one TA that is not part of the list of "forbidden tracking areas for roaming" [4], which belongs to a PLMN that fulfils the first bullet above;
- The cell selection criteria are fulfilled, see subclause 5.2.3.2;

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5.2 Cell selection and reselection

5.2.1 Introduction

UE shall perform measurements for cell selection and reselection purposes as specified in [10].

The NAS can control the RAT(s) in which the cell selection should be performed, for instance by indicating RAT(s) associated with the selected PLMN, and by maintaining a list of forbidden registration area(s) and a list of equivalent PLMNs. The UE shall select a suitable cell based on idle mode measurements and cell selection criteria.

In order to speed up the cell selection process, stored information for several RATs may be available in the UE.

When camped on a cell, the UE shall regularly search for a better cell according to the cell reselection criteria. If a better cell is found, that cell is selected. The change of cell may imply a change of RAT. Details on performance requirements for cell reselection can be found in [10].

The NAS is informed if the cell selection and reselection results in changes in the received system information relevant for NAS.

For normal service, the UE shall camp on a suitable cell, tune to that cell's control channel(s) so that the UE can:

- Receive system information from the PLMN; and
 - receive registration area information from the PLMN, e.g., tracking area information; and
 - receive other AS and NAS Information; and
- if registered:
 - receive paging and notification messages from the PLMN; and
 - initiate transfer to connected mode.

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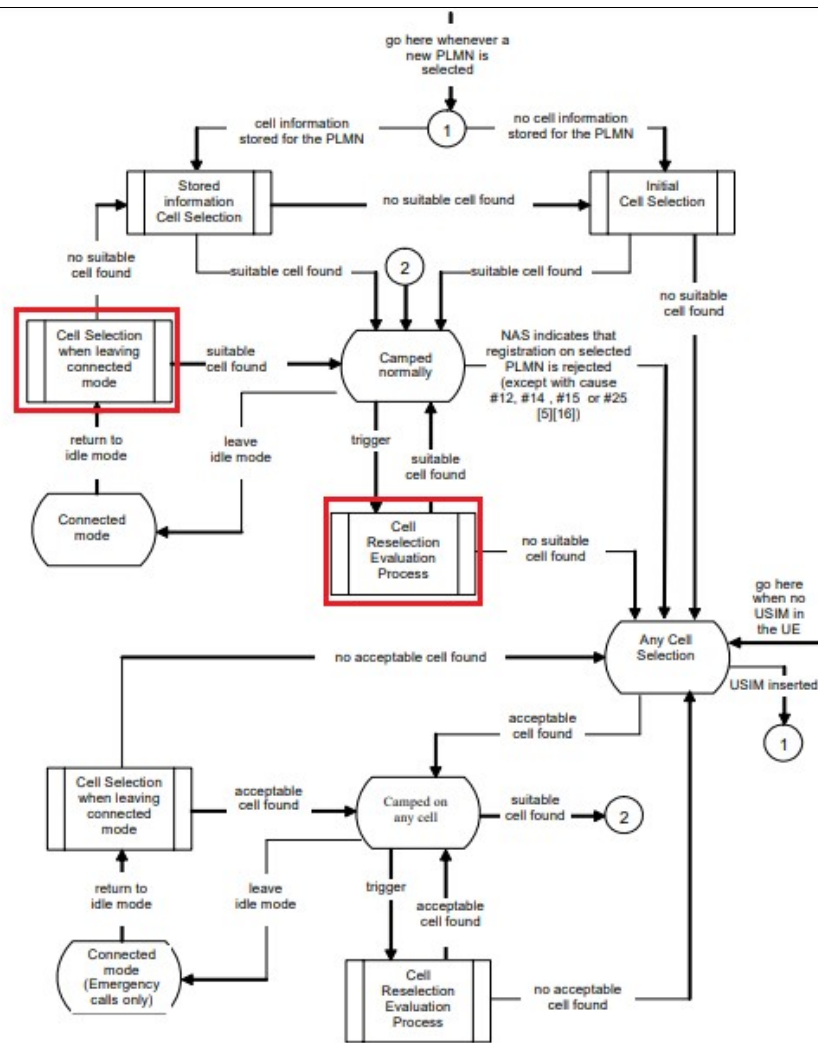


Figure 5.2.2-1: RRC_IDLE Cell Selection and Reselection

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5.2.4.5 E-UTRAN Inter-frequency and inter-RAT Cell Reselection criteria

Criteria 1: the $S_{\text{nonServingCell},x}$ of a cell on evaluated frequency is greater than $\text{Thresh}_{x,\text{high}}$ during a time interval $\text{Treselection}_{\text{RAT}}$;

Cell reselection to a cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- A cell of a higher priority E-UTRAN frequency or inter-RAT frequency fulfils criteria 1; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

Cell reselection to a cell on an equal priority E-UTRAN frequency shall be based on ranking for Intra-frequency cell reselection as defined in sub-clause 5.2.4.6.

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- No cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency fulfills the criteria 1; and
- No cell on serving frequency or on an equal priority E-UTRAN frequency fulfills the criteria in 5.2.4.6; and
- $S_{\text{ServingCell}} < \text{Thresh}_{\text{serving, low}}$ and the $S_{\text{nonServingCell},x}$ of a cell of a lower priority E-UTRAN frequency or inter-RAT frequency is greater than $\text{Thresh}_{x,\text{low}}$ during a time interval $\text{Treselection}_{\text{RAT}}$; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

For GERAN, UTRAN, and E-UTRAN, $S_{\text{nonServingCell},x}$ is the S_{rxlev} -value of an evaluated cell. For UTRAN FDD, S_{qual} is higher than 0, as defined in [8]. For cdma2000 RATs, $S_{\text{nonServingCell},x}$ is equal to $-\text{FLOOR}(-2 \times 10 \times \log_{10} E_c/I_o)$ in units of 0.5 dB, as defined in [18], with E_c/I_o referring to the value measured from the evaluated cell.

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5.2.4 Cell Reselection evaluation process

5.2.4.1 Reselection priorities handling

Absolute priorities of different E-UTRAN frequencies or inter-RAT frequencies may be provided to the UE in the system information, in the *RRCConnectionRelease* message, or by inheriting from another RAT at inter-RAT cell (re)selection. In the case of system information, an E-UTRAN frequency or inter-RAT frequency may be listed without providing a priority (i.e. the field *cellReselectionPriority* is absent for that frequency). If priorities are provided in dedicated signalling, the UE shall ignore all the priorities provided in system information. If UE is in *camped on any cell* state, UE shall only apply the priorities provided by system information from current cell, and the UE preserves priorities provided by dedicated signalling unless specified otherwise. When the UE in *camped normally* state, has only dedicated priorities other than for the current frequency, the UE shall consider the current frequency to be the lowest priority frequency (i.e. lower than the eight network configured values). While the UE is camped on a suitable CSG cell, the UE shall always consider the current frequency to be the highest priority frequency (i.e. higher than the eight network configured values), irrespective of any other priority value allocated to this frequency. The UE shall delete priorities provided by dedicated signalling when:

- the UE enters RRC_CONNECTED state; or
- the optional validity time of dedicated priorities (T320) expires; or
- a PLMN selection is performed on request by NAS [5].

NOTE: Equal priorities between RATs are not supported.

The UE shall only perform cell reselection evaluation for E-UTRAN frequencies and inter-RAT frequencies that are given in system information and for which the UE has a priority provided.

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5.2.4.2 Measurement rules for cell re-selection

When evaluating for reselection purposes cell selection criterion or $S_{\text{ServingCell},x}$, the UE shall use parameters provided by the serving cell.

Following rules are used by the UE to limit needed measurements:

- If $S_{\text{intrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{intrasearch}}$, UE may choose to not perform intra-frequency measurements.
- If $S_{\text{ServingCell}} \leq S_{\text{intrasearch}}$, or $S_{\text{intrasearch}}$ is not sent in the serving cell UE shall perform intra-frequency measurements.
- The UE shall apply the following rules for E-UTRAN inter-frequencies and inter-RAT frequencies which are indicated in system information and for which the UE has priority provided as defined in 5.2.4.1:
 - For an E-UTRAN inter-frequency or inter-RAT frequency with a reselection priority higher than the reselection priority of the current E-UTRA frequency the UE shall perform measurements of higher priority E-UTRAN inter-frequency or inter-RAT frequencies according to [10].

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- For an E-UTRAN inter-frequency with an equal or lower reselection priority than the reselection priority of the current E-UTRA frequency and for inter-RAT frequency with lower reselection priority than the reselection priority of the current E-UTRAN frequency:
 - If $S_{\text{nonintrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{nonintrasearch}}$ UE may choose not to perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority.
 - If $S_{\text{ServingCell}} \leq S_{\text{nonintrasearch}}$ or $S_{\text{nonintrasearch}}$ is not sent in the serving cell the UE shall perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority according to [10].

Where $S_{\text{ServingCell}}$ is the S_{rxlev} -value of the serving cell.

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The cell selection criterion S is fulfilled when:

$$S_{rxlev} > 0$$

Where:

$$S_{rxlev} = Q_{rxlevmeas} - (Q_{rxlevmin} + Q_{rxlevminoffset}) - P_{compensation}$$

Where:

the signalled value $Q_{rxlevminOffset}$ is only applied when a cell is evaluated for cell selection as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]. During this periodic search for higher priority PLMN the UE may check the S criteria of a cell using parameter values stored from a different cell of this higher priority PLMN.

S_{rxlev}	Cell Selection RX level value (dB)
$Q_{rxlevmeas}$	Measured cell RX level value (RSRP).
$Q_{rxlevmin}$	Minimum required RX level in the cell (dBm)
$Q_{rxlevminoffset}$	Offset to the signalled $Q_{rxlevmin}$ taken into account in the S_{rxlev} evaluation as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]
$P_{compensation}$	$\max(P_{EMAX} - P_{PowerClass}, 0)$ (dB)
P_{EMAX}	Maximum TX power level an UE may use when transmitting on the uplink in the cell (dBm) defined as P_{EMAX} in [TS 36.101]
$P_{PowerClass}$	Maximum RF output power of the UE (dBm) according to the UE power class as defined in [TS 36.101]

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4.2.2.4 Measurements of inter-frequency E-UTRAN cells

[Editor's note: The RAN2 measurement rules for inter frequency are still to be clarified . It is assumed that the following parameter is defined : $\text{Thresh}_{\text{serv_high}}$: Threshold for the LTE serving cell when the UE initiates measurements, or increases the measurement rate (in the case of high to low priority reselection) on a different E-UTRA frequency layer. This section should be reviewed and updated once more detailed measurement rules are defined by RAN2.]

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the RSRP of the E-UTRA serving cell (or other cells on the same frequency layer) is greater than $\text{Thresh}_{\text{serv_high}}$ then

- the UE may not search for, or measure inter-frequency or inter-RAT layers of equal or lower priority.

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- the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in section 4.2.2. *Editors note: The measurement of cells that are detected in this search is still to be described.*

If the RSRP of the E-UTRA serving cell is less than or equal to $\text{Thresh}_{\text{serv_high},x}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible reselection. In this scenario, the minimum rate at which the UE is required to search for and measure such layers is not reduced.

The UE shall be able to evaluate the need for reselection to a newly detectable inter-frequency cell within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving cells assuming that $T_{\text{reselection}} = 0$. The parameter K_{carrier} is the number of E-UTRA inter-frequency carriers indicated by the serving cell. It shall be possible to evaluate the need for reselection to cells which have:

- $\text{RSRP} \geq -\text{TBD dBm}$ and $\text{Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) \geq [-3] \text{ dB}$.
- $\text{SCH Ior} > -\text{TBD dBm}$ and $\text{SCH Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) > [-3] \text{ dB}$. The UE shall measure RSRP at least every $K_{\text{carrier}} * T_{\text{measure,EUTRAN_Inter}}$ DRX cycle (see table 4.2.2.3-1) for identified inter-frequency cells. If the UE detects on a E-UTRA carrier a cell whose physical identity is indicated as not allowed for that carrier in the measurement control system information of the serving cell, the UE is not required to perform measurements on that cell.

The UE shall filter RSRP measurements of each measured inter-frequency cell using at least [2] measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by at least $[T_{\text{measure,EUTRAN_Inter}}/2]$.

The UE shall not consider a E-UTRA neighbour cell in cell reselection, if it is indicated as not allowed in the measurement control system information of the serving cell.

The filtering shall be such that the UE shall be capable of evaluating that the inter-frequency cell has met reselection criterion defined TS 36.304 within $T_{\text{evaluateFDD,Inter}}$ as specified in table 4.2.2.4-1.

Table 4.2.2.4-1 : $T_{\text{detect,EUTRAN_Inter}}$, $T_{\text{measure,EUTRAN_Inter}}$ and $T_{\text{evaluateFDD,Inter}}$

DRX cycle length [s]	$T_{\text{detect,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{measure,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{evaluateFDD,Inter}}$ [s] (number of DRX cycles)
0.32	[11.52 (36)]	[1.28 (4)]	[5.12 (16)]
0.64	[17.92 (28)]	[1.28 (2)]	[5.12 (8)]
1.28	[32(25)]	[1.28 (1)]	[6.4 (5)]
2.56	[55.88 (23)]	[2.56 (1)]	[7.68 (3)]

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<p>determining at said remote station that the first signal metric of the first RS-received signal falls below a threshold, and that the second signal metric of the second RS-received signal is above the threshold, and that the second base station has available capacity, thereby determining to change base stations.</p>	<p>The accused product practices determining that the first signal metric (e.g., a first RSRP value related to a first reference signal) of the first RS-received signal (e.g., a first reference signal received from the serving cell) falls below a threshold, and that the second signal metric (e.g., a second RSRP value related to a second reference signal) of the second RS-received signal (e.g., a second reference signal received from a cell other than the serving cell) is above the threshold, and that the second base station has available capacity (e.g., the accused product determines that a cell other than the serving cell is suitable cell), thereby determining to change base stations (e.g., inter-frequency cell reselection).</p>
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4.2.3 E-UTRAN FDD - FDD cell re-selection inter frequency case

4.2.3.1 Test purpose

To verify that when the neighbour cell operates on a different carrier frequency, compared to the current cell the UE is able to search and measure cells to meet the inter-frequency cell re-selection requirements.

4.2.3.2 Test applicability

This test applies to all types of E-UTRA FDD UE release 8 and forward.

4.2.3.3 Minimum conformance requirements

The cell re-selection delay shall be less than $T_{\text{evaluate,E-UTRAN_Inter}} + T_{\text{SI-EUTRA}}$ in RRC_IDLE state.

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is greater than $S_{\text{nonintrasearch}}$ then the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher priority search}}$ where $T_{\text{higher priority search}}$ is described in TS 36.133 [4] clause 4.2.2 as $T_{\text{higher priority search}} = (60 * N_{\text{layers}})$ seconds, where the parameter N_{layers} is the total number of configured higher priority E-UTRA carrier frequencies.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is less than or equal to $S_{\text{nonintrasearch}}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible re-selection. In this scenario, the minimum rate at which the UE is required to search for and measure higher priority layers shall be the same as that defined below for lower or equal priority inter-frequency layers.

The UE shall be able to evaluate whether a newly detectable lower or equal priority inter-frequency cell meets the re-selection criteria defined in TS 36.304 [6] within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ (as defined in table 4.2.2.4-1 of TS 36.133 [4] clause 4.2.2.4) if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving

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- The UE searches the E-UTRA frequency bands and for each carrier frequency identifies the strongest cell. It reads cell system information broadcast to identify its PLMN(s):
- The UE may search each carrier in turn ('initial cell selection') or make use of stored information to shorten the search ('stored information cell selection').
- The UE seeks to identify a suitable cell; if it is not able to identify a suitable cell it seeks to identify an acceptable cell. When a suitable cell is found or if only an acceptable cell is found it camps on that cell and commence the cell reselection procedure:
 - A suitable cell is one for which the measured cell attributes satisfy the cell selection criteria; the cell PLMN is the selected PLMN, registered or an equivalent PLMN; the cell is not barred or reserved and the cell is not part of a tracking area which is in the list of 'forbidden tracking areas for roaming';
 - An acceptable cell is one for which the measured cell attributes satisfy the cell selection criteria and the cell is not barred;

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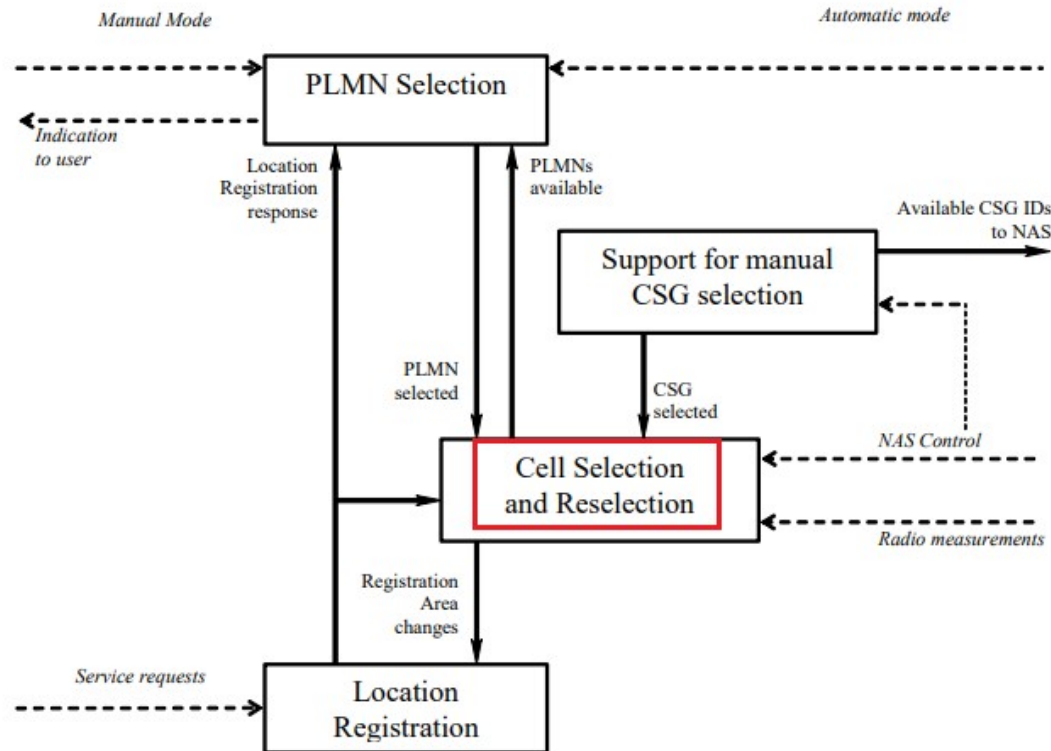


Figure 4.1-1: Overall Idle Mode process

When a UE is switched on, a public land mobile network (PLMN) is selected by NAS. For the selected PLMN, associated RAT(s) may be set [5]. The NAS shall provide a list of equivalent PLMNs, if available, that the AS shall use for cell selection and cell reselection.

With the cell selection, the UE searches for a suitable cell of the selected PLMN and chooses that cell to provide available services, further the UE shall tune to its control channel. This choosing is known as "camping on the cell".

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	<p>The UE shall, if necessary, then register its presence, by means of a NAS registration procedure, in the tracking area of the chosen cell and as outcome of a successful Location Registration the selected PLMN becomes the registered PLMN [5].</p> <p><u>If the UE finds a more suitable cell, according to the cell reselection criteria, it reselects onto that cell and camps on it. If the new cell does not belong to at least one tracking area to which the UE is registered, location registration is performed.</u></p> <p>If necessary, the UE shall search for higher priority PLMNs at regular time intervals as described in [4] and search for a suitable cell if another PLMN has been selected by NAS.</p> <p>Search of available CSGs may be triggered by NAS to support manual CSG selection within the registered PLMN.</p> <p>If the UE loses coverage of the registered PLMN, either a new PLMN is selected automatically (automatic mode), or an indication of which PLMNs are available is given to the user, so that a manual selection can be made (manual mode).</p> <p>Registration is not performed by UEs only capable of services that need no registration.</p> <p>https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf</p>
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	<div>Cell Selection</div>	<p>Control cell selection for example by indicating RAT(s) associated with the selected PLMN to be used initially in the search of a cell in the cell selection. NAS is also maintaining lists of forbidden registration areas and a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) and provide these lists to AS.</p>	<p>Perform measurements needed to support cell selection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Search for a suitable cell. The cells broadcast one or more 'PLMN identity' in the system information. Respond to NAS whether such cell is found or not.</p> <p>If associated RATs is (are) set for the PLMN, perform the search in this (these) RAT(s) and other RATs for that PLMN as specified in [5].</p> <p>If such a cell is found, the cell is selected to camp on.</p>
	<div>Cell Reselection</div>	<p>Control cell reselection by for example, maintaining lists of forbidden registration areas.</p> <p>Maintain a list of equivalent PLMN identities and provide the list to AS.</p> <p>Maintain a list of forbidden registration areas and provide the list to AS.</p> <p>Maintain a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) to camp and provide the list to AS.</p>	<div> <p>Perform measurements needed to support cell reselection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Change cell if a more suitable cell is found.</p> </div>

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suitable cell:

A "suitable cell" is a cell on which the UE may camp on to obtain normal service. Such a cell shall fulfil all the following requirements.

- The cell is part of either:
 - the selected PLMN, or:
 - the registered PLMN, or:
 - a PLMN of the Equivalent PLMN list
- For a CSG cell, the CSG ID broadcast by the cell is present in the allowed CSG list associated with the PLMN for which the above condition is satisfied;

According to the latest information provided by NAS:

- The cell is not barred, see subclause 5.3.1;
- The cell is part of at least one TA that is not part of the list of "forbidden tracking areas for roaming" [4], which belongs to a PLMN that fulfils the first bullet above;
- The cell selection criteria are fulfilled, see subclause 5.2.3.2;

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5.2 Cell selection and reselection

5.2.1 Introduction

UE shall perform measurements for cell selection and reselection purposes as specified in [10].

The NAS can control the RAT(s) in which the cell selection should be performed, for instance by indicating RAT(s) associated with the selected PLMN, and by maintaining a list of forbidden registration area(s) and a list of equivalent PLMNs. The UE shall select a suitable cell based on idle mode measurements and cell selection criteria.

In order to speed up the cell selection process, stored information for several RATs may be available in the UE.

When camped on a cell, the UE shall regularly search for a better cell according to the cell reselection criteria. If a better cell is found, that cell is selected. The change of cell may imply a change of RAT. Details on performance requirements for cell reselection can be found in [10].

The NAS is informed if the cell selection and reselection results in changes in the received system information relevant for NAS.

For normal service, the UE shall camp on a suitable cell, tune to that cell's control channel(s) so that the UE can:

- Receive system information from the PLMN; and
 - receive registration area information from the PLMN, e.g., tracking area information; and
 - receive other AS and NAS Information; and
- if registered:
 - receive paging and notification messages from the PLMN; and
 - initiate transfer to connected mode.

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

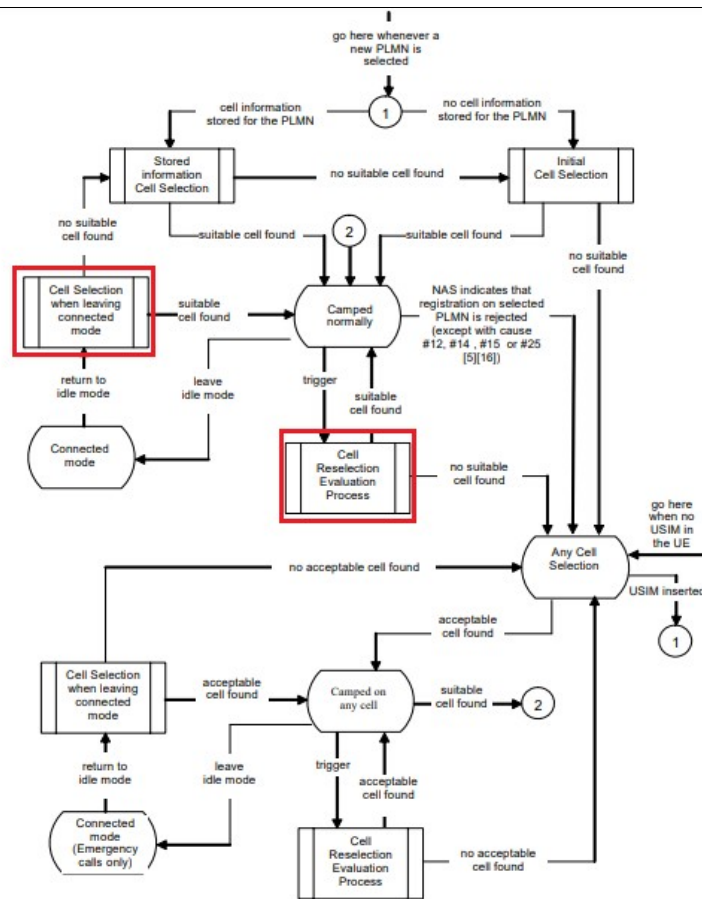


Figure 5.2.2-1: RRC_IDLE Cell Selection and Reselection

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

5.2.4.5 E-UTRAN Inter-frequency and inter-RAT Cell Reselection criteria

Criteria 1: the $S_{\text{nonServingCell},x}$ of a cell on evaluated frequency is greater than $\text{Thresh}_{x, \text{high}}$ during a time interval $\text{Treselection}_{\text{RAT}}$;

Cell reselection to a cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- A cell of a higher priority E-UTRAN frequency or inter-RAT frequency fulfils criteria 1; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

Cell reselection to a cell on an equal priority E-UTRAN frequency shall be based on ranking for Intra-frequency cell reselection as defined in sub-clause 5.2.4.6.

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- No cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency fulfills the criteria 1; and
- No cell on serving frequency or on an equal priority E-UTRAN frequency fulfills the criteria in 5.2.4.6; and
- $S_{\text{ServingCell}} < \text{Thresh}_{\text{serving, low}}$ and the $S_{\text{nonServingCell},x}$ of a cell of a lower priority E-UTRAN frequency or inter-RAT frequency is greater than $\text{Thresh}_{x, \text{low}}$ during a time interval $\text{Treselection}_{\text{RAT}}$; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

For GERAN, UTRAN, and E-UTRAN, $S_{\text{nonServingCell},x}$ is the S_{rxlev} -value of an evaluated cell. For UTRAN FDD, S_{qual} is higher than 0, as defined in [8]. For cdma2000 RATs, $S_{\text{nonServingCell},x}$ is equal to $-\text{FLOOR}(-2 \times 10 \times \log_{10} E_c/I_o)$ in units of 0.5 dB, as defined in [18], with E_c/I_o referring to the value measured from the evaluated cell.

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

5.2.4 Cell Reselection evaluation process

5.2.4.1 Reselection priorities handling

Absolute priorities of different E-UTRAN frequencies or inter-RAT frequencies may be provided to the UE in the system information, in the *RRCConnectionRelease* message, or by inheriting from another RAT at inter-RAT cell (re)selection. In the case of system information, an E-UTRAN frequency or inter-RAT frequency may be listed without providing a priority (i.e. the field *cellReselectionPriority* is absent for that frequency). If priorities are provided in dedicated signalling, the UE shall ignore all the priorities provided in system information. If UE is in *camped on any cell* state, UE shall only apply the priorities provided by system information from current cell, and the UE preserves priorities provided by dedicated signalling unless specified otherwise. When the UE in *camped normally* state, has only dedicated priorities other than for the current frequency, the UE shall consider the current frequency to be the lowest priority frequency (i.e. lower than the eight network configured values). While the UE is camped on a suitable CSG cell, the UE shall always consider the current frequency to be the highest priority frequency (i.e. higher than the eight network configured values), irrespective of any other priority value allocated to this frequency. The UE shall delete priorities provided by dedicated signalling when:

- the UE enters RRC_CONNECTED state; or
- the optional validity time of dedicated priorities (T320) expires; or
- a PLMN selection is performed on request by NAS [5].

NOTE: Equal priorities between RATs are not supported.

The UE shall only perform cell reselection evaluation for E-UTRAN frequencies and inter-RAT frequencies that are given in system information and for which the UE has a priority provided.

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

5.2.4.2 Measurement rules for cell re-selection

When evaluating for reselection purposes cell selection criterion or $S_{\text{ServingCell},x}$, the UE shall use parameters provided by the serving cell.

Following rules are used by the UE to limit needed measurements:

- If $S_{\text{intrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{intrasearch}}$, UE may choose to not perform intra-frequency measurements.
- If $S_{\text{ServingCell}} \leq S_{\text{intrasearch}}$, or $S_{\text{intrasearch}}$ is not sent in the serving cell UE shall perform intra-frequency measurements.
- The UE shall apply the following rules for E-UTRAN inter-frequencies and inter-RAT frequencies which are indicated in system information and for which the UE has priority provided as defined in 5.2.4.1:
 - For an E-UTRAN inter-frequency or inter-RAT frequency with a reselection priority higher than the reselection priority of the current E-UTRA frequency the UE shall perform measurements of higher priority E-UTRAN inter-frequency or inter-RAT frequencies according to [10].

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

- For an E-UTRAN inter-frequency with an equal or lower reselection priority than the reselection priority of the current E-UTRA frequency and for inter-RAT frequency with lower reselection priority than the reselection priority of the current E-UTRAN frequency:
 - If $S_{\text{nonintrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{nonintrasearch}}$ UE may choose not to perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority.
 - If $S_{\text{ServingCell}} \leq S_{\text{nonintrasearch}}$ or $S_{\text{nonintrasearch}}$ is not sent in the serving cell the UE shall perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority according to [10].

Where $S_{\text{ServingCell}}$ is the S_{rxlev} -value of the serving cell.

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

The cell selection criterion S is fulfilled when:

$$S_{rxlev} > 0$$

Where:

$$S_{rxlev} = Q_{rxlevmeas} - (Q_{rxlevmin} + Q_{rxlevminoffset}) - P_{compensation}$$

Where:

the signalled value $Q_{rxlevminOffset}$ is only applied when a cell is evaluated for cell selection as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]. During this periodic search for higher priority PLMN the UE may check the S criteria of a cell using parameter values stored from a different cell of this higher priority PLMN.

S_{rxlev}	Cell Selection RX level value (dB)
$Q_{rxlevmeas}$	Measured cell RX level value (RSRP).
$Q_{rxlevmin}$	Minimum required RX level in the cell (dBm)
$Q_{rxlevminoffset}$	Offset to the signalled $Q_{rxlevmin}$ taken into account in the S_{rxlev} evaluation as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]
$P_{compensation}$	$\max(P_{EMAX} - P_{PowerClass}, 0)$ (dB)
P_{EMAX}	Maximum TX power level an UE may use when transmitting on the uplink in the cell (dBm) defined as P_{EMAX} in [TS 36.101]
$P_{PowerClass}$	Maximum RF output power of the UE (dBm) according to the UE power class as defined in [TS 36.101]

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

4.2.2.4 Measurements of inter-frequency E-UTRAN cells

[Editor's note: The RAN2 measurement rules for inter frequency are still to be clarified . It is assumed that the following parameter is defined : $\text{Thresh}_{\text{serv_high}}$: Threshold for the LTE serving cell when the UE initiates measurements, or increases the measurement rate (in the case of high to low priority reselection) on a different E-UTRA frequency layer. This section should be reviewed and updated once more detailed measurement rules are defined by RAN2.]

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the RSRP of the E-UTRA serving cell (or other cells on the same frequency layer) is greater than $\text{Thresh}_{\text{serv_high}}$ then

- the UE may not search for, or measure inter-frequency or inter-RAT layers of equal or lower priority.

https://www.etsi.org/deliver/etsi_ts/136100_136199/136133/08.02.00_60/ts_136133v080200p.pdf

- the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in section 4.2.2. *Editors note: The measurement of cells that are detected in this search is still to be described.*

If the RSRP of the E-UTRA serving cell is less than or equal to $\text{Thresh}_{\text{serv_high},x}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible reselection. In this scenario, the minimum rate at which the UE is required to search for and measure such layers is not reduced.

The UE shall be able to evaluate the need for reselection to a newly detectable inter-frequency cell within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving cells assuming that $T_{\text{reselection}} = 0$. The parameter K_{carrier} is the number of E-UTRA inter-frequency carriers indicated by the serving cell. It shall be possible to evaluate the need for reselection to cells which have:

- $\text{RSRP} \geq -\text{TBD dBm}$ and $\text{Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) \geq [-3] \text{ dB}$.
- $\text{SCH Ior} > -\text{TBD dBm}$ and $\text{SCH Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) > [-3] \text{ dB}$. The UE shall measure RSRP at least every $K_{\text{carrier}} * T_{\text{measure,EUTRAN_Inter}}$ DRX cycle (see table 4.2.2.3-1) for identified inter-frequency cells. If the UE detects on a E-UTRA carrier a cell whose physical identity is indicated as not allowed for that carrier in the measurement control system information of the serving cell, the UE is not required to perform measurements on that cell.

The UE shall filter RSRP measurements of each measured inter-frequency cell using at least [2] measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by at least $[T_{\text{measure,EUTRAN_Inter}}/2]$.

The UE shall not consider a E-UTRA neighbour cell in cell reselection, if it is indicated as not allowed in the measurement control system information of the serving cell.

The filtering shall be such that the UE shall be capable of evaluating that the inter-frequency cell has met reselection criterion defined TS 36.304 within $T_{\text{evaluateFDD,Inter}}$ as specified in table 4.2.2.4-1.

Table 4.2.2.4-1 : $T_{\text{detect,EUTRAN_Inter}}$, $T_{\text{measure,EUTRAN_Inter}}$ and $T_{\text{evaluateFDD,Inter}}$

DRX cycle length [s]	$T_{\text{detect,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{measure,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{evaluateFDD,Inter}}$ [s] (number of DRX cycles)
0.32	[11.52 (36)]	[1.28 (4)]	[5.12 (16)]
0.64	[17.92 (28)]	[1.28 (2)]	[5.12 (8)]
1.28	[32(25)]	[1.28 (1)]	[6.4 (5)]
2.56	[55.88 (23)]	[2.56 (1)]	[7.68 (3)]

https://www.etsi.org/deliver/etsi_ts/136100_136199/136133/08.02.00_60/ts_136133v080200p.pdf

	<p>3GPP TS 36.300 version 8.7.0 Release 8 43 ETSI TS 136 300 V8.7.0 (2009-01)</p> <ul style="list-style-type: none"> - The UE searches the E-UTRA frequency bands and for each carrier frequency identifies the strongest cell. It reads cell system information broadcast to identify its PLMN(s): - The UE may search each carrier in turn ('initial cell selection') or make use of stored information to shorten the search ('stored information cell selection'). - The UE seeks to identify a suitable cell; if it is not able to identify a suitable cell it seeks to identify an acceptable cell. When a suitable cell is found or if only an acceptable cell is found it camps on that cell and commence the cell reselection procedure: - A suitable cell is one for which the measured cell attributes satisfy the cell selection criteria; the cell PLMN is the selected PLMN, registered or an equivalent PLMN; the cell is not barred or reserved and the cell is not part of a tracking area which is in the list of 'forbidden tracking areas for roaming'; - An acceptable cell is one for which the measured cell attributes satisfy the cell selection criteria and the cell is not barred; <p>https://www.etsi.org/deliver/etsi_ts/136300_136399/136300/08.07.00_60/ts_136300v080700p.pdf</p>
6. An improvement to a spread-spectrum system comprising:	<p>A system utilized by the accused product is an improvement to a spread-spectrum system.</p> <p>The accused product has LTE-FDD and 802.11b/g/n capabilities.</p>



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- **Comprehensive Certifications** for FCC, IC & PTCRB and co-located radio certification
- **Industrial temperature range** (-30° to +70° C)
- **Advanced deployment tools** including intuitive web-based configuration and integrated presets for multiple external LoRa Network Server vendors
- **Enterprise-grade security** built on our years of experience in wireless
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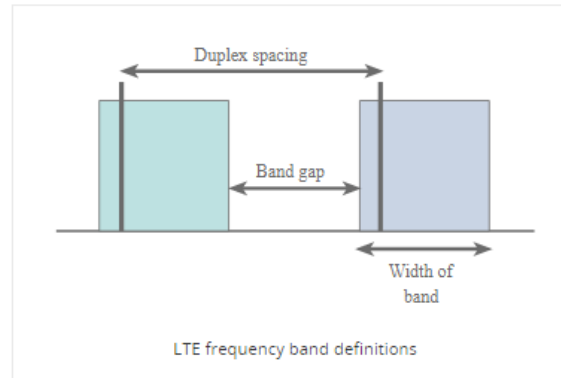
As shown below, the accused product works on LTE frequency band number 2,4,5,12,13 among others. These band numbers correspond to LTE FDD as outlined below.

- **LTE CAT 1 M.2 card** – 3GPP Release 11, Bands B2/4/5/12/13 supported – North America Region
- **Full Linux operating system** – Kernel v4.x running on Atmel A5 Core @ 536 MHz
- **Multiple interfaces** such as LTE CAT 1, LoRaWAN, Wi-Fi 802.11a/b/g/n and Ethernet
- **8-Channel LoRaWAN support** with up to +27 dBm max TX power
- **Comprehensive Certifications** for FCC, IC & PTCRB and co-located radio certification
- **Industrial temperature range** (-30° to +70° C)
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FDD LTE frequency band allocations

There is a large number of allocations or radio spectrum that has been reserved for FDD, frequency division duplex, LTE use.



<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/frequency-bands-channels-spectrum.php>

FDD LTE BANDS & FREQUENCIES

LTE BAND NUMBER	UPLINK (MHZ)	DOWNLINK (MHZ)	WIDTH OF BAND (MHZ)	DUPLEX SPACING (MHZ)	BAND GAP (MHZ)
1	1920 - 1980	2110 - 2170	60	190	130
2	1850 - 1910	1930 - 1990	60	80	20
3	1710 - 1785	1805 - 1880	75	95	20
4	1710 - 1755	2110 - 2155	45	400	355
5	824 - 849	869 - 894	25	45	20
6	830 - 840	875 - 885	10	35	25
7	2500 - 2570	2620 - 2690	70	120	50
8	880 - 915	925 - 960	35	45	10
9	1749.9 - 1784.9	1844.9 - 1879.9	35	95	60
10	1710 - 1770	2110 - 2170	60	400	340
11	1427.9 - 1452.9	1475.9 - 1500.9	20	48	28
12	698 - 716	728 - 746	18	30	12
13	777 - 787	746 - 756	10	-31	41
14	788 - 798	758 - 768	10	-30	40
15	1900 - 1920	2600 - 2620	20	700	680
16	2010 - 2025	2585 - 2600	15	575	560
17	704 - 716	734 - 746	12	30	18
18	815 - 830	860 - 875	15	45	30
19	830 - 845	875 - 890	15	45	30
20	832 - 862	791 - 821	30	-41	71
21	1447.9 - 1462.9	1495.5 - 1510.9	15	48	33

<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/frequency-bands-channels-spectrum.php>

To achieve high radio spectral efficiency as well as enable efficient scheduling in both time and frequency domain, a multicarrier approach for multiple access was chosen by 3GPP. For the downlink, OFDMA (Orthogonal Frequency Division Multiple Access) was selected and for the uplink SC-FDMA (Single Carrier - Frequency Division Multiple Access) also known as DFT (Discrete Fourier Transform) spread OFDMA (figure 3).



Figure 3 OFDMA and SC-FDMA

OFDM is a multicarrier technology subdividing the available bandwidth into a multitude of mutual orthogonal narrowband subcarriers. In OFDMA these subcarriers can be shared between multiple users. The OFDMA solution leads to high Peak-to-Average Power Ratio (PAPR) requiring expensive power amplifiers with high requirements on linearity, increasing the power consumption for the sender. This is no problem in the eNB, but would lead to very expensive handsets. Hence a different solution was selected for the UL. As illustrated in figure 3, the SC-FDMA solution generates a signal with single carrier characteristics, hence with a low PAPR.

<https://www.3gpp.org/technologies/keywords-acronyms/98-lte>

If we then examine the Fourier transform of our functions given in equation (8.6), we obtain a sinc function of pseudo-period T_p , which means that in the frequency domain subcarriers are spaced exactly such that the peak of the next one corresponds to the previous one's first zero – see figure 8.3.

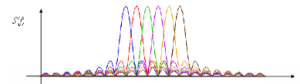


Figure 8.3: OFDM subcarrier spacing.

The overall envelope looks a bit like a spread spectrum signal, and may be tapered further to reduce out of band spectral power density.

<http://morse.colorado.edu/~tlen5510/text/classwebch8.html>

Since the subcarriers that carry data are transmitted at a low rate, with higher symbol time, OFDM is more resilient to multipath effects. Therefore, it is more suitable for wide-area non-line of sight wireless access technology.

Also, using overlapping orthogonal subcarriers without guard bands makes it more efficient than the FDM scheme in terms of bits per Hertz. OFDM is a spread-spectrum technology in which energy generated at a particular bandwidth is spread across a wider bandwidth making it more resilient to interference and “jamming”.

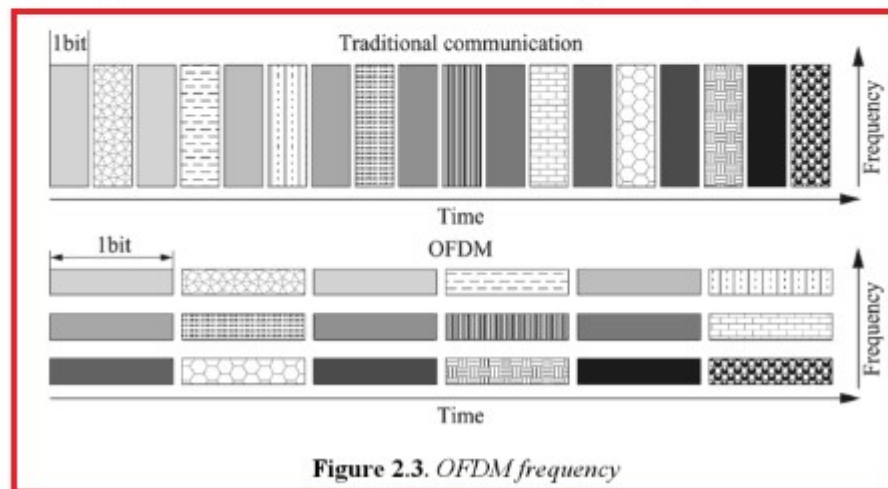


Figure 2.3. OFDM frequency

Source: "LTE Standards" By Jean-Gabriel Rémy, Charlotte Letamendia
<https://onlinelibrary.wiley.com/doi/book/10.1002/9781119043508>

a frequency division duplex (FDD), distributed network;

The system utilized by the accused product comprises a frequency division duplex (FDD), distributed network (e.g., a network comprising the accused product with 802.11b/g/n capability, another product/device to which the accused product can communicate via 802.11b/g/n communication, and several base stations).

To enable possible deployment around the world, supporting as many regulatory requirements as possible, LTE is developed for a number of frequency bands – E-UTRA operating bands- currently ranging from 700 MHz up to 2.7GHz. The available bandwidths are also flexible starting with 1.4 MHz up to 20 MHz. LTE is developed to support both the time division duplex technology (TDD) as well as frequency division duplex (FDD). In R8 there are 15 bands specified for FDD and eight bands for TDD. In R9 four bands were added for FDD. Also added in R9 were for example Multimedia Broadcast Multicast Service (MBMS), and Home eNB (HeNB), see figure 4. MBMS is used to provide broadcast information to all users, for example advertisement, and multicast to a closed group subscribing to a specific service, e.g. streaming TV. HeNBs are introduced mainly to provide coverage indoors, in homes or offices. The HeNB is a low power eNB that will be used in small cells – femto cells. Normally it will be owned by the customer, deployed without any network planning and connected to the operators EPC (Evolved Packet Core).

<https://www.3gpp.org/technologies/keywords-acronyms/98-lte>

LTE can utilise both FDD - frequency division duplex and TDD - time division duplex, often referred to as TD-LTE.

Both forms of duplex, FDD and TDD have their advantages and the areas where their deployment is advantageous.

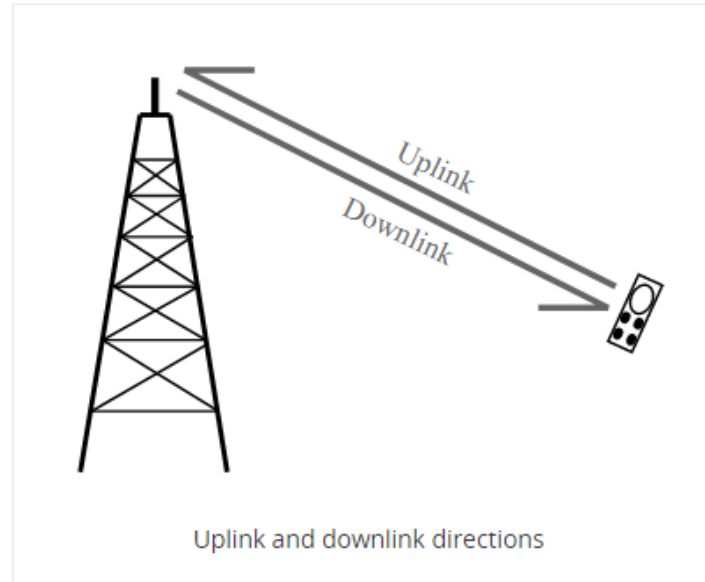
For most normal LTE deployments the frequency division duplex, FDD is used, and paired spectrum with equal bandwidth in up and downlinks is utilised.

LTE FDD using the paired spectrum was considered to be the migration path for the UMTS 3G services which typically utilised paired spectrum.

However there was considerable development placed on the time division duplex form of LTE: TDD LTE or TD-LTE which was seen as the upgrade path for TD-SCDMA that was developed and introduced by the Chinese as a 3G technology.

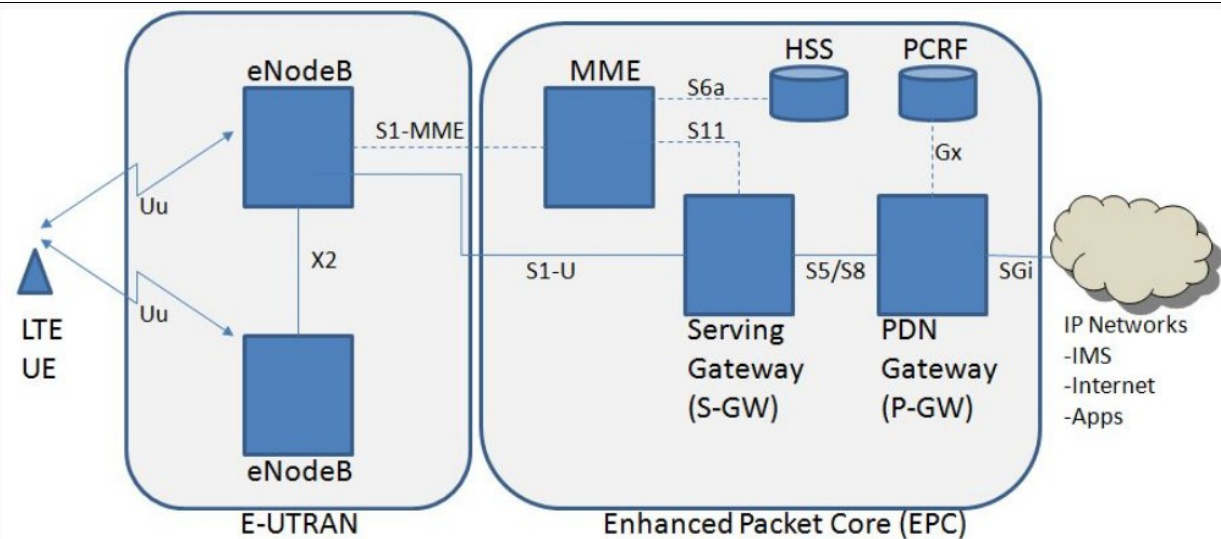
<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/tdd-fdd-td-lte-duplex-schemes.php>

- **Uplink:** the transmission from the UE or user equipment to the eNodeB or base station.
- **Downlink** the transmission from the eNodeB or base station to the UE or user equipment.

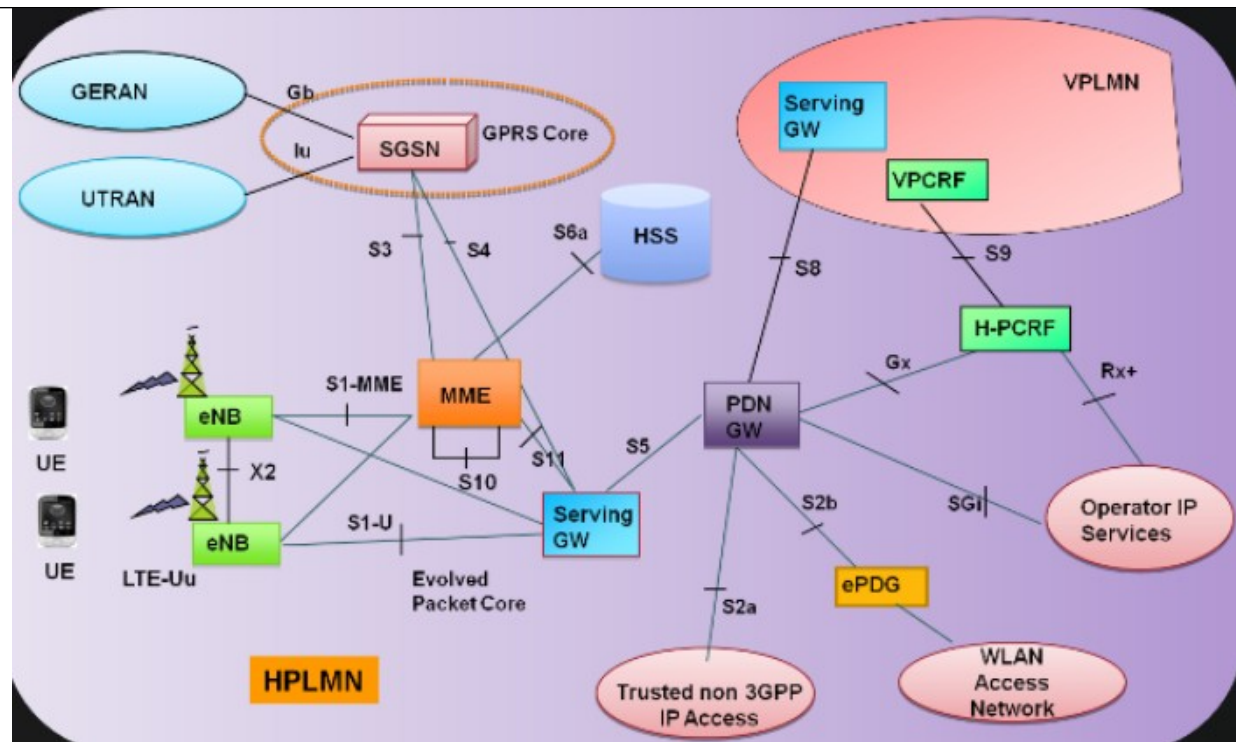


In order to be able to be able to transmit in both directions, a user equipment or base station must have a duplex scheme. There are two forms of duplex that are commonly used, namely FDD, frequency division duplex and TDD time division duplex..

<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/tdd-fdd-td-lte-duplex-schemes.php>



<https://www.rcrwireless.com/20140509/evolved-packet-core-epc/lte-network-diagram#prettyPhoto/5/>



<http://hershengq.blogspot.com/2012/03/architecture-of-lte-network-and-working.html>

a first base station (BS), located in, and part of, the FDD distributed network, for transmitting, using radio waves, a first BS-packet signal at a first frequency;

The system utilized by the accused product comprises a first base station (BS) (e.g., a serving cell for a user equipment), located in, and part of, the FDD distributed network, for transmitting, using radio waves, a first BS-packet signal (e.g., a reference signal) at a first frequency (e.g., a first frequency).

4.2.3 E-UTRAN FDD - FDD cell re-selection inter frequency case

4.2.3.1 Test purpose

To verify that when the neighbour cell operates on a different carrier frequency, compared to the current cell the UE is able to search and measure cells to meet the inter-frequency cell re-selection requirements.

4.2.3.2 Test applicability

This test applies to all types of E-UTRA FDD UE release 8 and forward.

4.2.3.3 Minimum conformance requirements

The cell re-selection delay shall be less than $T_{\text{evaluate,E-UTRAN_Inter}} + T_{\text{SI-EUTRA}}$ in RRC_IDLE state.

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is greater than $S_{\text{nonintrasearch}}$ then the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher priority search}}$ where $T_{\text{higher priority search}}$ is described in TS 36.133 [4] clause 4.2.2 as $T_{\text{higher priority search}} = (60 * N_{\text{layers}})$ seconds, where the parameter N_{layers} is the total number of configured higher priority E-UTRA carrier frequencies.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is less than or equal to $S_{\text{nonintrasearch}}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible re-selection. In this scenario, the minimum rate at which the UE is required to search for and measure higher priority layers shall be the same as that defined below for lower or equal priority inter-frequency layers.

The UE shall be able to evaluate whether a newly detectable lower or equal priority inter-frequency cell meets the re-selection criteria defined in TS 36.304 [6] within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ (as defined in table 4.2.2.4-1 of TS 36.133 [4] clause 4.2.2.4) if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving

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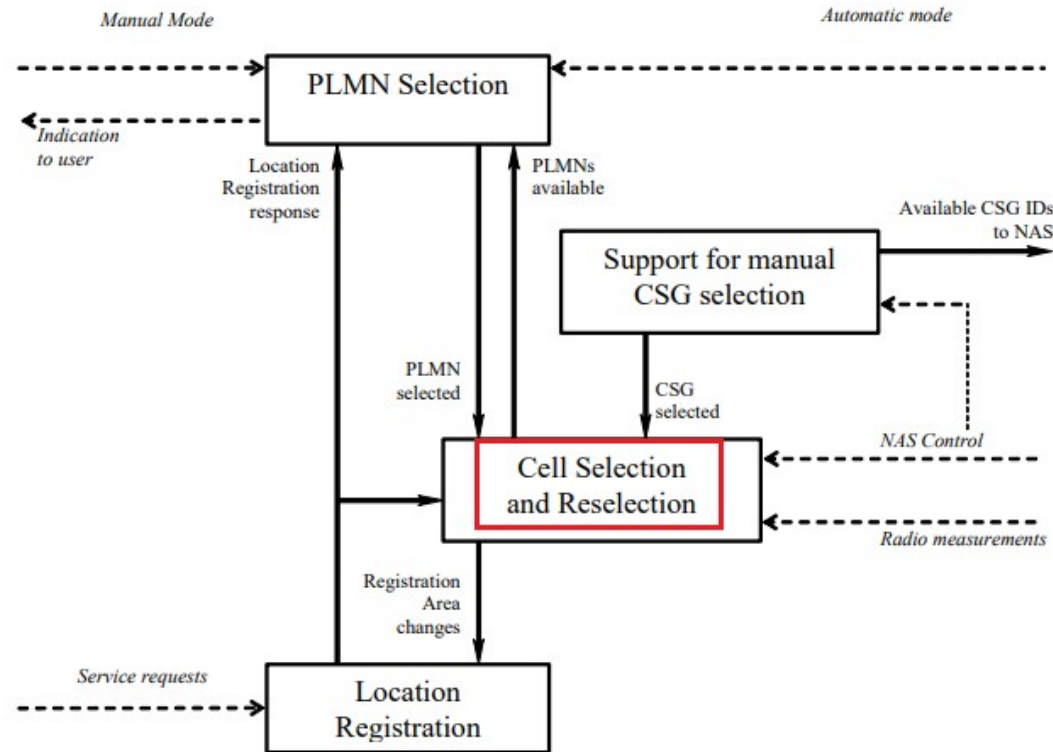


Figure 4.1-1: Overall Idle Mode process

When a UE is switched on, a public land mobile network (PLMN) is selected by NAS. For the selected PLMN, associated RAT(s) may be set [5]. The NAS shall provide a list of equivalent PLMNs, if available, that the AS shall use for cell selection and cell reselection.

With the cell selection, the UE searches for a suitable cell of the selected PLMN and chooses that cell to provide available services, further the UE shall tune to its control channel. This choosing is known as "camping on the cell".

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	<p>The UE shall, if necessary, then register its presence, by means of a NAS registration procedure, in the tracking area of the chosen cell and as outcome of a successful Location Registration the selected PLMN becomes the registered PLMN [5].</p> <p><u>If the UE finds a more suitable cell, according to the cell reselection criteria, it reselects onto that cell and camps on it. If the new cell does not belong to at least one tracking area to which the UE is registered, location registration is performed.</u></p> <p>If necessary, the UE shall search for higher priority PLMNs at regular time intervals as described in [4] and search for a suitable cell if another PLMN has been selected by NAS.</p> <p>Search of available CSGs may be triggered by NAS to support manual CSG selection within the registered PLMN.</p> <p>If the UE loses coverage of the registered PLMN, either a new PLMN is selected automatically (automatic mode), or an indication of which PLMNs are available is given to the user, so that a manual selection can be made (manual mode).</p> <p>Registration is not performed by UEs only capable of services that need no registration.</p> <p>https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf</p>
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	<div>Cell Selection</div>	<p>Control cell selection for example by indicating RAT(s) associated with the selected PLMN to be used initially in the search of a cell in the cell selection. NAS is also maintaining lists of forbidden registration areas and a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) and provide these lists to AS.</p>	<p>Perform measurements needed to support cell selection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Search for a suitable cell. The cells broadcast one or more 'PLMN identity' in the system information. Respond to NAS whether such cell is found or not.</p> <p>If associated RATs is (are) set for the PLMN, perform the search in this (these) RAT(s) and other RATs for that PLMN as specified in [5].</p> <p>If such a cell is found, the cell is selected to camp on.</p>
	<div>Cell Reselection</div>	<p>Control cell reselection by for example, maintaining lists of forbidden registration areas.</p> <p>Maintain a list of equivalent PLMN identities and provide the list to AS.</p> <p>Maintain a list of forbidden registration areas and provide the list to AS.</p> <p>Maintain a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) to camp and provide the list to AS.</p>	<div> <p>Perform measurements needed to support cell reselection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Change cell if a more suitable cell is found.</p> </div>

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suitable cell:

A "suitable cell" is a cell on which the UE may camp on to obtain normal service. Such a cell shall fulfil all the following requirements.

- The cell is part of either:
 - the selected PLMN, or:
 - the registered PLMN, or:
 - a PLMN of the Equivalent PLMN list
- For a CSG cell, the CSG ID broadcast by the cell is present in the allowed CSG list associated with the PLMN for which the above condition is satisfied;

According to the latest information provided by NAS:

- The cell is not barred, see subclause 5.3.1;
- The cell is part of at least one TA that is not part of the list of "forbidden tracking areas for roaming" [4], which belongs to a PLMN that fulfils the first bullet above;
- The cell selection criteria are fulfilled, see subclause 5.2.3.2;

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5.2 Cell selection and reselection

5.2.1 Introduction

UE shall perform measurements for cell selection and reselection purposes as specified in [10].

The NAS can control the RAT(s) in which the cell selection should be performed, for instance by indicating RAT(s) associated with the selected PLMN, and by maintaining a list of forbidden registration area(s) and a list of equivalent PLMNs. The UE shall select a suitable cell based on idle mode measurements and cell selection criteria.

In order to speed up the cell selection process, stored information for several RATs may be available in the UE.

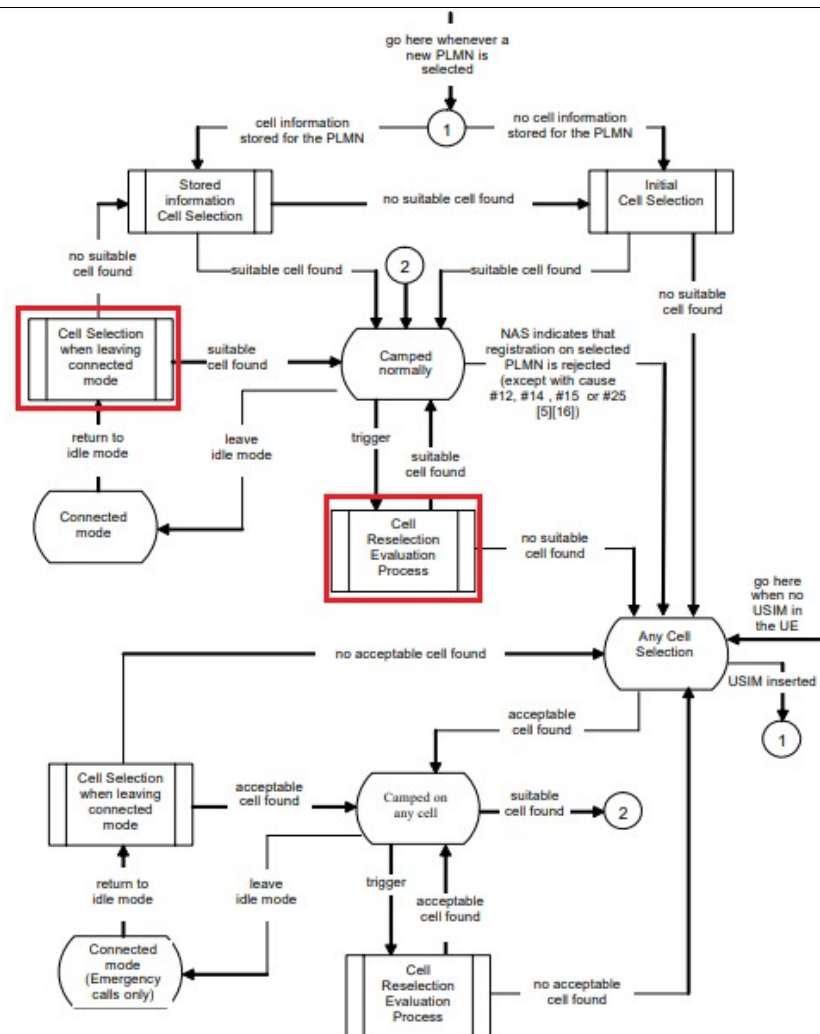
When camped on a cell, the UE shall regularly search for a better cell according to the cell reselection criteria. If a better cell is found, that cell is selected. The change of cell may imply a change of RAT. Details on performance requirements for cell reselection can be found in [10].

The NAS is informed if the cell selection and reselection results in changes in the received system information relevant for NAS.

For normal service, the UE shall camp on a suitable cell, tune to that cell's control channel(s) so that the UE can:

- Receive system information from the PLMN; and
 - receive registration area information from the PLMN, e.g., tracking area information; and
 - receive other AS and NAS Information; and
- if registered:
 - receive paging and notification messages from the PLMN; and
 - initiate transfer to connected mode.

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5.2.4.5 E-UTRAN Inter-frequency and inter-RAT Cell Reselection criteria

Criteria 1: the $S_{\text{nonServingCell},x}$ of a cell on evaluated frequency is greater than $\text{Thresh}_{x,\text{high}}$ during a time interval $\text{Treselection}_{\text{RAT}}$;

Cell reselection to a cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- A cell of a higher priority E-UTRAN frequency or inter-RAT frequency fulfils criteria 1; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

Cell reselection to a cell on an equal priority E-UTRAN frequency shall be based on ranking for Intra-frequency cell reselection as defined in sub-clause 5.2.4.6.

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- No cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency fulfills the criteria 1; and
- No cell on serving frequency or on an equal priority E-UTRAN frequency fulfills the criteria in 5.2.4.6; and
- $S_{\text{ServingCell}} < \text{Thresh}_{\text{serving, low}}$ and the $S_{\text{nonServingCell},x}$ of a cell of a lower priority E-UTRAN frequency or inter-RAT frequency is greater than $\text{Thresh}_{x,\text{low}}$ during a time interval $\text{Treselection}_{\text{RAT}}$; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

For GERAN, UTRAN, and E-UTRAN, $S_{\text{nonServingCell},x}$ is the S_{rxlev} -value of an evaluated cell. For UTRAN FDD, S_{qual} is higher than 0, as defined in [8]. For cdma2000 RATs, $S_{\text{nonServingCell},x}$ is equal to $-\text{FLOOR}(-2 \times 10 \times \log_{10} E_c/I_o)$ in units of 0.5 dB, as defined in [18], with E_c/I_o referring to the value measured from the evaluated cell.

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5.2.4 Cell Reselection evaluation process

5.2.4.1 Reselection priorities handling

Absolute priorities of different E-UTRAN frequencies or inter-RAT frequencies may be provided to the UE in the system information, in the *RRCConnectionRelease* message, or by inheriting from another RAT at inter-RAT cell (re)selection. In the case of system information, an E-UTRAN frequency or inter-RAT frequency may be listed without providing a priority (i.e. the field *cellReselectionPriority* is absent for that frequency). If priorities are provided in dedicated signalling, the UE shall ignore all the priorities provided in system information. If UE is in *camped on any cell* state, UE shall only apply the priorities provided by system information from current cell, and the UE preserves priorities provided by dedicated signalling unless specified otherwise. When the UE in *camped normally* state, has only dedicated priorities other than for the current frequency, the UE shall consider the current frequency to be the lowest priority frequency (i.e. lower than the eight network configured values). While the UE is camped on a suitable CSG cell, the UE shall always consider the current frequency to be the highest priority frequency (i.e. higher than the eight network configured values), irrespective of any other priority value allocated to this frequency. The UE shall delete priorities provided by dedicated signalling when:

- the UE enters RRC_CONNECTED state; or
- the optional validity time of dedicated priorities (T320) expires; or
- a PLMN selection is performed on request by NAS [5].

NOTE: Equal priorities between RATs are not supported.

The UE shall only perform cell reselection evaluation for E-UTRAN frequencies and inter-RAT frequencies that are given in system information and for which the UE has a priority provided.

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5.2.4.2 Measurement rules for cell re-selection

When evaluating for reselection purposes cell selection criterion or $S_{\text{ServingCell},x}$, the UE shall use parameters provided by the serving cell.

Following rules are used by the UE to limit needed measurements:

- If $S_{\text{intrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{intrasearch}}$, UE may choose to not perform intra-frequency measurements.
- If $S_{\text{ServingCell}} \leq S_{\text{intrasearch}}$, or $S_{\text{intrasearch}}$ is not sent in the serving cell UE shall perform intra-frequency measurements.
- The UE shall apply the following rules for E-UTRAN inter-frequencies and inter-RAT frequencies which are indicated in system information and for which the UE has priority provided as defined in 5.2.4.1:
 - For an E-UTRAN inter-frequency or inter-RAT frequency with a reselection priority higher than the reselection priority of the current E-UTRA frequency the UE shall perform measurements of higher priority E-UTRAN inter-frequency or inter-RAT frequencies according to [10].

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- For an E-UTRAN inter-frequency with an equal or lower reselection priority than the reselection priority of the current E-UTRA frequency and for inter-RAT frequency with lower reselection priority than the reselection priority of the current E-UTRAN frequency:
 - If $S_{\text{nonintrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{nonintrasearch}}$ UE may choose not to perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority.
 - If $S_{\text{ServingCell}} \leq S_{\text{nonintrasearch}}$ or $S_{\text{nonintrasearch}}$ is not sent in the serving cell the UE shall perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority according to [10].

Where $S_{\text{ServingCell}}$ is the S_{rxlev} -value of the serving cell.

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The cell selection criterion S is fulfilled when:

$$S_{rxlev} > 0$$

Where:

$$S_{rxlev} = Q_{rxlevmeas} - (Q_{rxlevmin} + Q_{rxlevminoffset}) - P_{compensation}$$

Where:

the signalled value $Q_{rxlevminOffset}$ is only applied when a cell is evaluated for cell selection as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]. During this periodic search for higher priority PLMN the UE may check the S criteria of a cell using parameter values stored from a different cell of this higher priority PLMN.

S_{rxlev}	Cell Selection RX level value (dB)
$Q_{rxlevmeas}$	Measured cell RX level value (RSRP).
$Q_{rxlevmin}$	Minimum required RX level in the cell (dBm)
$Q_{rxlevminoffset}$	Offset to the signalled $Q_{rxlevmin}$ taken into account in the S_{rxlev} evaluation as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]
$P_{compensation}$	$\max(P_{EMAX} - P_{PowerClass}, 0)$ (dB)
P_{EMAX}	Maximum TX power level an UE may use when transmitting on the uplink in the cell (dBm) defined as P_{EMAX} in [TS 36.101]
$P_{PowerClass}$	Maximum RF output power of the UE (dBm) according to the UE power class as defined in [TS 36.101]

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4.2.2.4 Measurements of inter-frequency E-UTRAN cells

[Editor's note: The RAN2 measurement rules for inter frequency are still to be clarified . It is assumed that the following parameter is defined : $\text{Thresh}_{\text{serving_high}}$: Threshold for the LTE serving cell when the UE initiates measurements, or increases the measurement rate (in the case of high to low priority reselection) on a different E-UTRA frequency layer. This section should be reviewed and updated once more detailed measurement rules are defined by RAN2.]

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the RSRP of the E-UTRA serving cell (or other cells on the same frequency layer) is greater than $\text{Thresh}_{\text{serving_high}}$ then

- the UE may not search for, or measure inter-frequency or inter-RAT layers of equal or lower priority.

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- the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in section 4.2.2. *Editors note: The measurement of cells that are detected in this search is still to be described.*

If the RSRP of the E-UTRA serving cell is less than or equal to $\text{Thresh}_{\text{serv_high},x}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible reselection. In this scenario, the minimum rate at which the UE is required to search for and measure such layers is not reduced.

The UE shall be able to evaluate the need for reselection to a newly detectable inter-frequency cell within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving cells assuming that $T_{\text{reselection}} = 0$. The parameter K_{carrier} is the number of E-UTRA inter-frequency carriers indicated by the serving cell. It shall be possible to evaluate the need for reselection to cells which have:

- $\text{RSRP} \geq -\text{TBD dBm}$ and $\text{Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) \geq [-3] \text{ dB}$.
- $\text{SCH Ior} > -\text{TBD dBm}$ and $\text{SCH Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) > [-3] \text{ dB}$. The UE shall measure RSRP at least every $K_{\text{carrier}} * T_{\text{measure,EUTRAN_Inter}}$ DRX cycle (see table 4.2.2.3-1) for identified inter-frequency cells. If the UE detects on a E-UTRA carrier a cell whose physical identity is indicated as not allowed for that carrier in the measurement control system information of the serving cell, the UE is not required to perform measurements on that cell.

The UE shall filter RSRP measurements of each measured inter-frequency cell using at least [2] measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by at least $[T_{\text{measure,EUTRAN_Inter}}/2]$.

The UE shall not consider a E-UTRA neighbour cell in cell reselection, if it is indicated as not allowed in the measurement control system information of the serving cell.

The filtering shall be such that the UE shall be capable of evaluating that the inter-frequency cell has met reselection criterion defined TS 36.304 within $T_{\text{evaluateFDD,Inter}}$ as specified in table 4.2.2.4-1.

Table 4.2.2.4-1 : $T_{\text{detect,EUTRAN_Inter}}$, $T_{\text{measure,EUTRAN_Inter}}$ and $T_{\text{evaluateFDD,Inter}}$

DRX cycle length [s]	$T_{\text{detect,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{measure,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{evaluateFDD,Inter}}$ [s] (number of DRX cycles)
0.32	[11.52 (36)]	[1.28 (4)]	[5.12 (16)]
0.64	[17.92 (28)]	[1.28 (2)]	[5.12 (8)]
1.28	[32(25)]	[1.28 (1)]	[6.4 (5)]
2.56	[55.88 (23)]	[2.56 (1)]	[7.68 (3)]

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a second base station, located in, and part of, the FDD distributed network, for transmitting, using radio waves, a second BS-packet signal at a second frequency, with the second frequency different from the first frequency;

The system utilized by the accused product comprises a second base station (e.g., a cell other than the serving cell of a user equipment), located in, and part of, the FDD distributed network, for transmitting, using radio waves, a second BS-packet signal (e.g., a reference signal) at a second frequency (e.g., inter-frequency cell reselection, a cell operates at different carrier frequency than the serving cell of a user equipment) , with the second frequency different from the first frequency.

4.2.3 E-UTRAN FDD - FDD cell re-selection inter frequency case

4.2.3.1 Test purpose

To verify that when the neighbour cell operates on a different carrier frequency, compared to the current cell the UE is able to search and measure cells to meet the inter-frequency cell re-selection requirements.

4.2.3.2 Test applicability

This test applies to all types of E-UTRA FDD UE release 8 and forward.

4.2.3.3 Minimum conformance requirements

The cell re-selection delay shall be less than $T_{\text{evaluate,E-UTRAN_Inter}} + T_{\text{SI-EUTRA}}$ in RRC_IDLE state.

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is greater than $S_{\text{nonintrasearch}}$ then the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher priority search}}$ where $T_{\text{higher priority search}}$ is described in TS 36.133 [4] clause 4.2.2 as $T_{\text{higher priority search}} = (60 * N_{\text{layers}})$ seconds, where the parameter N_{layers} is the total number of configured higher priority E-UTRA carrier frequencies.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is less than or equal to $S_{\text{nonintrasearch}}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible re-selection. In this scenario, the minimum rate at which the UE is required to search for and measure higher priority layers shall be the same as that defined below for lower or equal priority inter-frequency layers.

The UE shall be able to evaluate whether a newly detectable lower or equal priority inter-frequency cell meets the re-selection criteria defined in TS 36.304 [6] within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ (as defined in table 4.2.2.4-1 of TS 36.133 [4] clause 4.2.2.4) if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving

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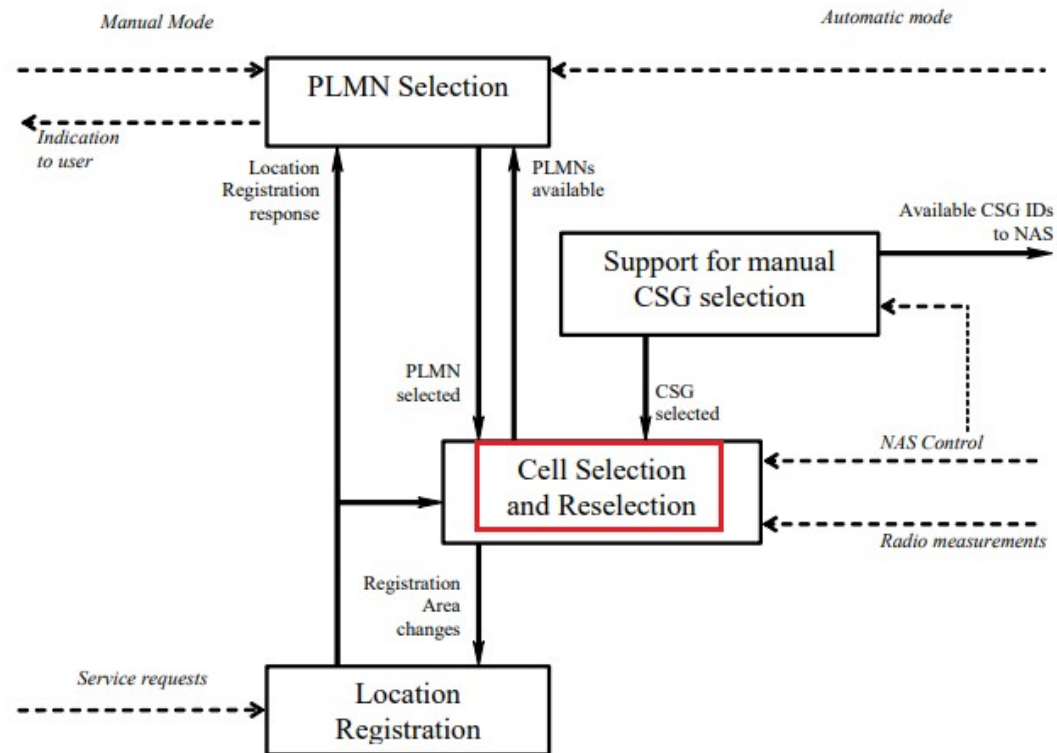


Figure 4.1-1: Overall Idle Mode process

When a UE is switched on, a public land mobile network (PLMN) is selected by NAS. For the selected PLMN, associated RAT(s) may be set [5]. The NAS shall provide a list of equivalent PLMNs, if available, that the AS shall use for cell selection and cell reselection.

With the cell selection, the UE searches for a suitable cell of the selected PLMN and chooses that cell to provide available services, further the UE shall tune to its control channel. This choosing is known as "camping on the cell".

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	<p>The UE shall, if necessary, then register its presence, by means of a NAS registration procedure, in the tracking area of the chosen cell and as outcome of a successful Location Registration the selected PLMN becomes the registered PLMN [5].</p> <p><u>If the UE finds a more suitable cell, according to the cell reselection criteria, it reselects onto that cell and camps on it. If the new cell does not belong to at least one tracking area to which the UE is registered, location registration is performed.</u></p> <p>If necessary, the UE shall search for higher priority PLMNs at regular time intervals as described in [4] and search for a suitable cell if another PLMN has been selected by NAS.</p> <p>Search of available CSGs may be triggered by NAS to support manual CSG selection within the registered PLMN.</p> <p>If the UE loses coverage of the registered PLMN, either a new PLMN is selected automatically (automatic mode), or an indication of which PLMNs are available is given to the user, so that a manual selection can be made (manual mode).</p> <p>Registration is not performed by UEs only capable of services that need no registration.</p> <p>https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf</p>
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	<div>Cell Selection</div>	<p>Control cell selection for example by indicating RAT(s) associated with the selected PLMN to be used initially in the search of a cell in the cell selection. NAS is also maintaining lists of forbidden registration areas and a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) and provide these lists to AS.</p>	<p>Perform measurements needed to support cell selection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Search for a suitable cell. The cells broadcast one or more 'PLMN identity' in the system information. Respond to NAS whether such cell is found or not.</p> <p>If associated RATs is (are) set for the PLMN, perform the search in this (these) RAT(s) and other RATs for that PLMN as specified in [5].</p> <p>If such a cell is found, the cell is selected to camp on.</p>
	<div>Cell Reselection</div>	<p>Control cell reselection by for example, maintaining lists of forbidden registration areas.</p> <p>Maintain a list of equivalent PLMN identities and provide the list to AS.</p> <p>Maintain a list of forbidden registration areas and provide the list to AS.</p> <p>Maintain a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) to camp and provide the list to AS.</p>	<div> <p>Perform measurements needed to support cell reselection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Change cell if a more suitable cell is found.</p> </div>

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suitable cell:

A "suitable cell" is a cell on which the UE may camp on to obtain normal service. Such a cell shall fulfil all the following requirements.

- The cell is part of either:
 - the selected PLMN, or:
 - the registered PLMN, or:
 - a PLMN of the Equivalent PLMN list
- For a CSG cell, the CSG ID broadcast by the cell is present in the allowed CSG list associated with the PLMN for which the above condition is satisfied;

According to the latest information provided by NAS:

- The cell is not barred, see subclause 5.3.1;
- The cell is part of at least one TA that is not part of the list of "forbidden tracking areas for roaming" [4], which belongs to a PLMN that fulfils the first bullet above;
- The cell selection criteria are fulfilled, see subclause 5.2.3.2;

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5.2 Cell selection and reselection

5.2.1 Introduction

UE shall perform measurements for cell selection and reselection purposes as specified in [10].

The NAS can control the RAT(s) in which the cell selection should be performed, for instance by indicating RAT(s) associated with the selected PLMN, and by maintaining a list of forbidden registration area(s) and a list of equivalent PLMNs. The UE shall select a suitable cell based on idle mode measurements and cell selection criteria.

In order to speed up the cell selection process, stored information for several RATs may be available in the UE.

When camped on a cell, the UE shall regularly search for a better cell according to the cell reselection criteria. If a better cell is found, that cell is selected. The change of cell may imply a change of RAT. Details on performance requirements for cell reselection can be found in [10].

The NAS is informed if the cell selection and reselection results in changes in the received system information relevant for NAS.

For normal service, the UE shall camp on a suitable cell, tune to that cell's control channel(s) so that the UE can:

- Receive system information from the PLMN; and
 - receive registration area information from the PLMN, e.g., tracking area information; and
 - receive other AS and NAS Information; and
- if registered:
 - receive paging and notification messages from the PLMN; and
 - initiate transfer to connected mode.

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5.2.4.5 E-UTRAN Inter-frequency and inter-RAT Cell Reselection criteria

Criteria 1: the $S_{\text{nonServingCell},x}$ of a cell on evaluated frequency is greater than $\text{Thresh}_{x,\text{high}}$ during a time interval $\text{Treselection}_{\text{RAT}}$;

Cell reselection to a cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- A cell of a higher priority E-UTRAN frequency or inter-RAT frequency fulfils criteria 1; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

Cell reselection to a cell on an equal priority E-UTRAN frequency shall be based on ranking for Intra-frequency cell reselection as defined in sub-clause 5.2.4.6.

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- No cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency fulfills the criteria 1; and
- No cell on serving frequency or on an equal priority E-UTRAN frequency fulfills the criteria in 5.2.4.6; and
- $S_{\text{ServingCell}} < \text{Thresh}_{\text{serving, low}}$ and the $S_{\text{nonServingCell},x}$ of a cell of a lower priority E-UTRAN frequency or inter-RAT frequency is greater than $\text{Thresh}_{x,\text{low}}$ during a time interval $\text{Treselection}_{\text{RAT}}$; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

For GERAN, UTRAN, and E-UTRAN, $S_{\text{nonServingCell},x}$ is the S_{rxlev} -value of an evaluated cell. For UTRAN FDD, S_{qual} is higher than 0, as defined in [8]. For cdma2000 RATs, $S_{\text{nonServingCell},x}$ is equal to $-\text{FLOOR}(-2 \times 10 \times \log_{10} E_c/I_o)$ in units of 0.5 dB, as defined in [18], with E_c/I_o referring to the value measured from the evaluated cell.

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5.2.4 Cell Reselection evaluation process

5.2.4.1 Reselection priorities handling

Absolute priorities of different E-UTRAN frequencies or inter-RAT frequencies may be provided to the UE in the system information, in the *RRCConnectionRelease* message, or by inheriting from another RAT at inter-RAT cell (re)selection. In the case of system information, an E-UTRAN frequency or inter-RAT frequency may be listed without providing a priority (i.e. the field *cellReselectionPriority* is absent for that frequency). If priorities are provided in dedicated signalling, the UE shall ignore all the priorities provided in system information. If UE is in *camped on any cell* state, UE shall only apply the priorities provided by system information from current cell, and the UE preserves priorities provided by dedicated signalling unless specified otherwise. When the UE in *camped normally* state, has only dedicated priorities other than for the current frequency, the UE shall consider the current frequency to be the lowest priority frequency (i.e. lower than the eight network configured values). While the UE is camped on a suitable CSG cell, the UE shall always consider the current frequency to be the highest priority frequency (i.e. higher than the eight network configured values), irrespective of any other priority value allocated to this frequency. The UE shall delete priorities provided by dedicated signalling when:

- the UE enters RRC_CONNECTED state; or
- the optional validity time of dedicated priorities (T320) expires; or
- a PLMN selection is performed on request by NAS [5].

NOTE: Equal priorities between RATs are not supported.

The UE shall only perform cell reselection evaluation for E-UTRAN frequencies and inter-RAT frequencies that are given in system information and for which the UE has a priority provided.

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5.2.4.2 Measurement rules for cell re-selection

When evaluating for reselection purposes cell selection criterion or $S_{\text{ServingCell},x}$, the UE shall use parameters provided by the serving cell.

Following rules are used by the UE to limit needed measurements:

- If $S_{\text{intrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{intrasearch}}$, UE may choose to not perform intra-frequency measurements.
- If $S_{\text{ServingCell}} \leq S_{\text{intrasearch}}$, or $S_{\text{intrasearch}}$ is not sent in the serving cell UE shall perform intra-frequency measurements.
- The UE shall apply the following rules for E-UTRAN inter-frequencies and inter-RAT frequencies which are indicated in system information and for which the UE has priority provided as defined in 5.2.4.1:
 - For an E-UTRAN inter-frequency or inter-RAT frequency with a reselection priority higher than the reselection priority of the current E-UTRA frequency the UE shall perform measurements of higher priority E-UTRAN inter-frequency or inter-RAT frequencies according to [10].

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- For an E-UTRAN inter-frequency with an equal or lower reselection priority than the reselection priority of the current E-UTRA frequency and for inter-RAT frequency with lower reselection priority than the reselection priority of the current E-UTRAN frequency:
 - If $S_{\text{nonintrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{nonintrasearch}}$ UE may choose not to perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority.
 - If $S_{\text{ServingCell}} \leq S_{\text{nonintrasearch}}$ or $S_{\text{nonintrasearch}}$ is not sent in the serving cell the UE shall perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority according to [10].

Where $S_{\text{ServingCell}}$ is the S_{rxlev} -value of the serving cell.

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The cell selection criterion S is fulfilled when:

$$S_{rxlev} > 0$$

Where:

$$S_{rxlev} = Q_{rxlevmeas} - (Q_{rxlevmin} + Q_{rxlevminoffset}) - P_{compensation}$$

Where:

the signalled value $Q_{rxlevminOffset}$ is only applied when a cell is evaluated for cell selection as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]. During this periodic search for higher priority PLMN the UE may check the S criteria of a cell using parameter values stored from a different cell of this higher priority PLMN.

S_{rxlev}	Cell Selection RX level value (dB)
$Q_{rxlevmeas}$	Measured cell RX level value (RSRP).
$Q_{rxlevmin}$	Minimum required RX level in the cell (dBm)
$Q_{rxlevminoffset}$	Offset to the signalled $Q_{rxlevmin}$ taken into account in the S_{rxlev} evaluation as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]
$P_{compensation}$	$\max(P_{EMAX} - P_{PowerClass}, 0)$ (dB)
P_{EMAX}	Maximum TX power level an UE may use when transmitting on the uplink in the cell (dBm) defined as P_{EMAX} in [TS 36.101]
$P_{PowerClass}$	Maximum RF output power of the UE (dBm) according to the UE power class as defined in [TS 36.101]

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4.2.2.4 Measurements of inter-frequency E-UTRAN cells

[Editor's note: The RAN2 measurement rules for inter frequency are still to be clarified . It is assumed that the following parameter is defined : $\text{Thresh}_{\text{serv_high}}$: Threshold for the LTE serving cell when the UE initiates measurements, or increases the measurement rate (in the case of high to low priority reselection) on a different E-UTRA frequency layer. This section should be reviewed and updated once more detailed measurement rules are defined by RAN2.]

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the RSRP of the E-UTRA serving cell (or other cells on the same frequency layer) is greater than $\text{Thresh}_{\text{serv_high}}$ then

- the UE may not search for, or measure inter-frequency or inter-RAT layers of equal or lower priority.

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- the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in section 4.2.2. *Editors note: The measurement of cells that are detected in this search is still to be described.*

If the RSRP of the E-UTRA serving cell is less than or equal to $\text{Thresh}_{\text{serv_high},x}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible reselection. In this scenario, the minimum rate at which the UE is required to search for and measure such layers is not reduced.

The UE shall be able to evaluate the need for reselection to a newly detectable inter-frequency cell within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving cells assuming that $T_{\text{reselection}} = 0$. The parameter K_{carrier} is the number of E-UTRA inter-frequency carriers indicated by the serving cell. It shall be possible to evaluate the need for reselection to cells which have:

- $\text{RSRP} \geq -\text{TBD dBm}$ and $\text{Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) \geq [-3] \text{ dB}$.
- $\text{SCH Ior} > -\text{TBD dBm}$ and $\text{SCH Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) > [-3] \text{ dB}$. The UE shall measure RSRP at least every $K_{\text{carrier}} * T_{\text{measure,EUTRAN_Inter}}$ DRX cycle (see table 4.2.2.3-1) for identified inter-frequency cells. If the UE detects on a E-UTRA carrier a cell whose physical identity is indicated as not allowed for that carrier in the measurement control system information of the serving cell, the UE is not required to perform measurements on that cell.

The UE shall filter RSRP measurements of each measured inter-frequency cell using at least [2] measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by at least $[T_{\text{measure,EUTRAN_Inter}}/2]$.

The UE shall not consider a E-UTRA neighbour cell in cell reselection, if it is indicated as not allowed in the measurement control system information of the serving cell.

The filtering shall be such that the UE shall be capable of evaluating that the inter-frequency cell has met reselection criterion defined TS 36.304 within $T_{\text{evaluateFDD,Inter}}$ as specified in table 4.2.2.4-1.

Table 4.2.2.4-1 : $T_{\text{detect,EUTRAN_Inter}}$, $T_{\text{measure,EUTRAN_Inter}}$ and $T_{\text{evaluateFDD,Inter}}$

DRX cycle length [s]	$T_{\text{detect,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{measure,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{evaluateFDD,Inter}}$ [s] (number of DRX cycles)
0.32	[11.52 (36)]	[1.28 (4)]	[5.12 (16)]
0.64	[17.92 (28)]	[1.28 (2)]	[5.12 (8)]
1.28	[32(25)]	[1.28 (1)]	[6.4 (5)]
2.56	[55.88 (23)]	[2.56 (1)]	[7.68 (3)]

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a remote station (RS) for receiving the first BS-packet signal and the second BS-packet signal, and thereby determining a first RS-received signal and a second RS-received signal, respectively; and

The system utilized by the accused product comprises a remote station (RS) (e.g., the accused product) for receiving the first BS-packet signal (e.g., a first reference signal from the serving cell) and the second BS-packet signal (e.g., a second reference signal from a cell other than the serving cell), and thereby determining a first RS-received signal (e.g., a demodulated signal from a first reference signal received from the serving cell to determine RSRP value for inter-frequency cell reselection) to determine and a second RS-received signal (e.g., a demodulated signal from a second reference signal received from a cell other than the serving cell to determine RSRP value for inter-frequency cell reselection), respectively.



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- **Industrial temperature range** (-30° to +70° C)
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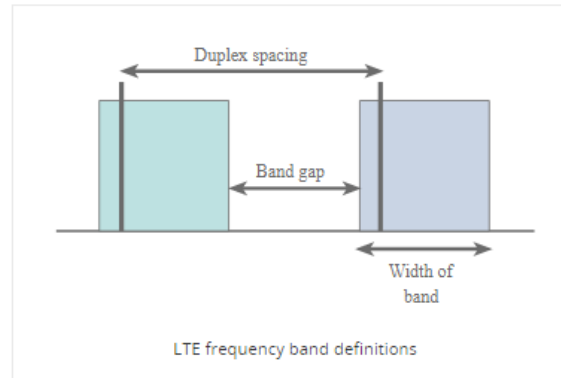
As shown below, the accused product works on LTE frequency band number 2,4,5,12,13 among others. These band numbers correspond to LTE FDD as outlined below.

- **LTE CAT 1 M.2 card** – 3GPP Release 11, Bands B2/4/5/12/13 supported – North America Region
- **Full Linux operating system** – Kernel v4.x running on Atmel A5 Core @ 536 MHz
- **Multiple interfaces** such as LTE CAT 1, LoRaWAN, Wi-Fi 802.11a/b/g/n and Ethernet
- **8-Channel LoRaWAN support** with up to +27 dBm max TX power
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- **Advanced deployment tools** including intuitive web-based configuration and integrated presets for multiple external LoRa Network Server vendors
- **Enterprise-grade security** built on our years of experience in wireless
- **Industry-leading support** works directly with our engineers to help deploy your design

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FDD LTE frequency band allocations

There is a large number of allocations or radio spectrum that has been reserved for FDD, frequency division duplex, LTE use.



<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/frequency-bands-channels-spectrum.php>

FDD LTE BANDS & FREQUENCIES

LTE BAND NUMBER	UPLINK (MHZ)	DOWNLINK (MHZ)	WIDTH OF BAND (MHZ)	DUPLEX SPACING (MHZ)	BAND GAP (MHZ)
1	1920 - 1980	2110 - 2170	60	190	130
2	1850 - 1910	1930 - 1990	60	80	20
3	1710 - 1785	1805 - 1880	75	95	20
4	1710 - 1755	2110 - 2155	45	400	355
5	824 - 849	869 - 894	25	45	20
6	830 - 840	875 - 885	10	35	25
7	2500 - 2570	2620 - 2690	70	120	50
8	880 - 915	925 - 960	35	45	10
9	1749.9 - 1784.9	1844.9 - 1879.9	35	95	60
10	1710 - 1770	2110 - 2170	60	400	340
11	1427.9 - 1452.9	1475.9 - 1500.9	20	48	28
12	698 - 716	728 - 746	18	30	12
13	777 - 787	746 - 756	10	-31	41
14	788 - 798	758 - 768	10	-30	40
15	1900 - 1920	2600 - 2620	20	700	680
16	2010 - 2025	2585 - 2600	15	575	560
17	704 - 716	734 - 746	12	30	18
18	815 - 830	860 - 875	15	45	30
19	830 - 845	875 - 890	15	45	30
20	832 - 862	791 - 821	30	-41	71
21	1447.9 - 1462.9	1495.5 - 1510.9	15	48	33

<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/frequency-bands-channels-spectrum.php>

4.2.3 E-UTRAN FDD - FDD cell re-selection inter frequency case

4.2.3.1 Test purpose

To verify that when the neighbour cell operates on a different carrier frequency, compared to the current cell the UE is able to search and measure cells to meet the inter-frequency cell re-selection requirements.

4.2.3.2 Test applicability

This test applies to all types of E-UTRA FDD UE release 8 and forward.

4.2.3.3 Minimum conformance requirements

The cell re-selection delay shall be less than $T_{\text{evaluate,E-UTRAN_Inter}} + T_{\text{SI-EUTRA}}$ in RRC_IDLE state.

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is greater than $S_{\text{nonintrasearch}}$ then the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in TS 36.133 [4] clause 4.2.2 as $T_{\text{higher_priority_search}} = (60 * N_{\text{layers}})$ seconds, where the parameter N_{layers} is the total number of configured higher priority E-UTRA carrier frequencies.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is less than or equal to $S_{\text{nonintrasearch}}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible re-selection. In this scenario, the minimum rate at which the UE is required to search for and measure higher priority layers shall be the same as that defined below for lower or equal priority inter-frequency layers.

The UE shall be able to evaluate whether a newly detectable lower or equal priority inter-frequency cell meets the re-selection criteria defined in TS 36.304 [6] within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ (as defined in table 4.2.2.4-1 of TS 36.133 [4] clause 4.2.2.4) if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving

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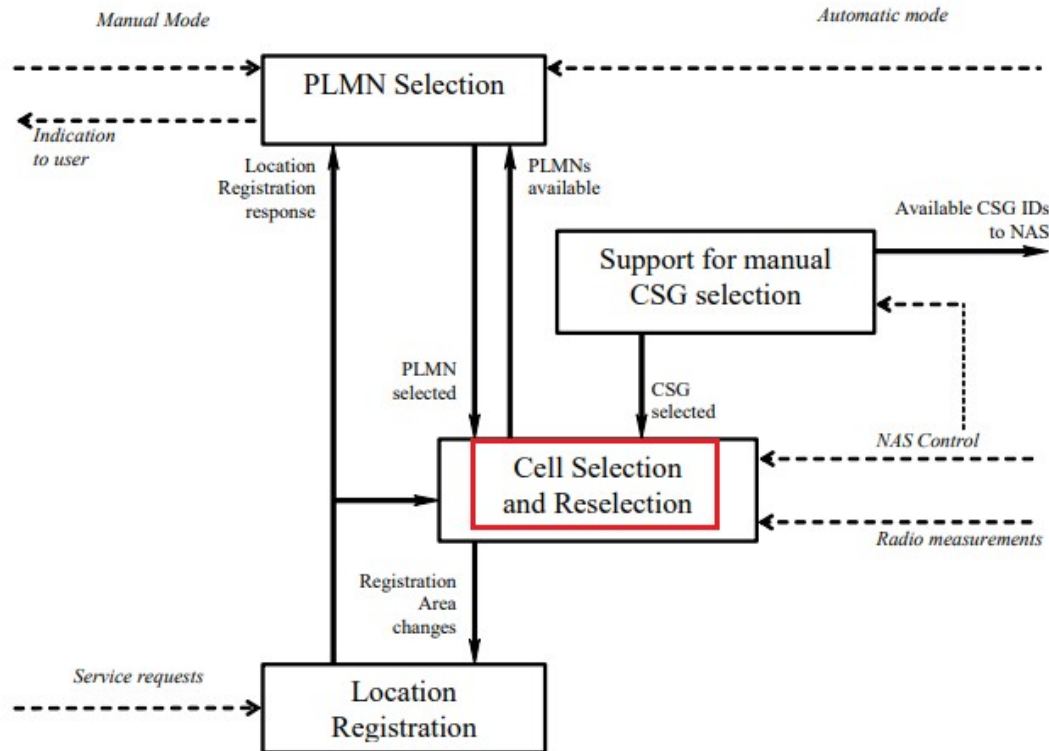


Figure 4.1-1: Overall Idle Mode process

When a UE is switched on, a public land mobile network (PLMN) is selected by NAS. For the selected PLMN, associated RAT(s) may be set [5]. The NAS shall provide a list of equivalent PLMNs, if available, that the AS shall use for cell selection and cell reselection.

With the cell selection, the UE searches for a suitable cell of the selected PLMN and chooses that cell to provide available services, further the UE shall tune to its control channel. This choosing is known as "camping on the cell".

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	<p>The UE shall, if necessary, then register its presence, by means of a NAS registration procedure, in the tracking area of the chosen cell and as outcome of a successful Location Registration the selected PLMN becomes the registered PLMN [5].</p> <p><u>If the UE finds a more suitable cell, according to the cell reselection criteria, it reselects onto that cell and camps on it. If the new cell does not belong to at least one tracking area to which the UE is registered, location registration is performed.</u></p> <p>If necessary, the UE shall search for higher priority PLMNs at regular time intervals as described in [4] and search for a suitable cell if another PLMN has been selected by NAS.</p> <p>Search of available CSGs may be triggered by NAS to support manual CSG selection within the registered PLMN.</p> <p>If the UE loses coverage of the registered PLMN, either a new PLMN is selected automatically (automatic mode), or an indication of which PLMNs are available is given to the user, so that a manual selection can be made (manual mode).</p> <p>Registration is not performed by UEs only capable of services that need no registration.</p> <p>https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf</p>
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	Cell Selection	Control cell selection for example by indicating RAT(s) associated with the selected PLMN to be used initially in the search of a cell in the cell selection. NAS is also maintaining lists of forbidden registration areas and a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) and provide these lists to AS.	<p>Perform measurements needed to support cell selection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Search for a suitable cell. The cells broadcast one or more 'PLMN identity' in the system information. Respond to NAS whether such cell is found or not.</p> <p>If associated RATs is (are) set for the PLMN, perform the search in this (these) RAT(s) and other RATs for that PLMN as specified in [5].</p> <p>If such a cell is found, the cell is selected to camp on.</p>
	Cell Reselection	<p>Control cell reselection by for example, maintaining lists of forbidden registration areas.</p> <p>Maintain a list of equivalent PLMN identities and provide the list to AS.</p> <p>Maintain a list of forbidden registration areas and provide the list to AS.</p> <p>Maintain a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) to camp and provide the list to AS.</p>	<p>Perform measurements needed to support cell reselection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Change cell if a more suitable cell is found.</p>

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suitable cell:

A "suitable cell" is a cell on which the UE may camp on to obtain normal service. Such a cell shall fulfil all the following requirements.

- The cell is part of either:
 - the selected PLMN, or:
 - the registered PLMN, or:
 - a PLMN of the Equivalent PLMN list
- For a CSG cell, the CSG ID broadcast by the cell is present in the allowed CSG list associated with the PLMN for which the above condition is satisfied;

According to the latest information provided by NAS:

- The cell is not barred, see subclause 5.3.1;
- The cell is part of at least one TA that is not part of the list of "forbidden tracking areas for roaming" [4], which belongs to a PLMN that fulfils the first bullet above;
- The cell selection criteria are fulfilled, see subclause 5.2.3.2;

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5.2 Cell selection and reselection

5.2.1 Introduction

UE shall perform measurements for cell selection and reselection purposes as specified in [10].

The NAS can control the RAT(s) in which the cell selection should be performed, for instance by indicating RAT(s) associated with the selected PLMN, and by maintaining a list of forbidden registration area(s) and a list of equivalent PLMNs. The UE shall select a suitable cell based on idle mode measurements and cell selection criteria.

In order to speed up the cell selection process, stored information for several RATs may be available in the UE.

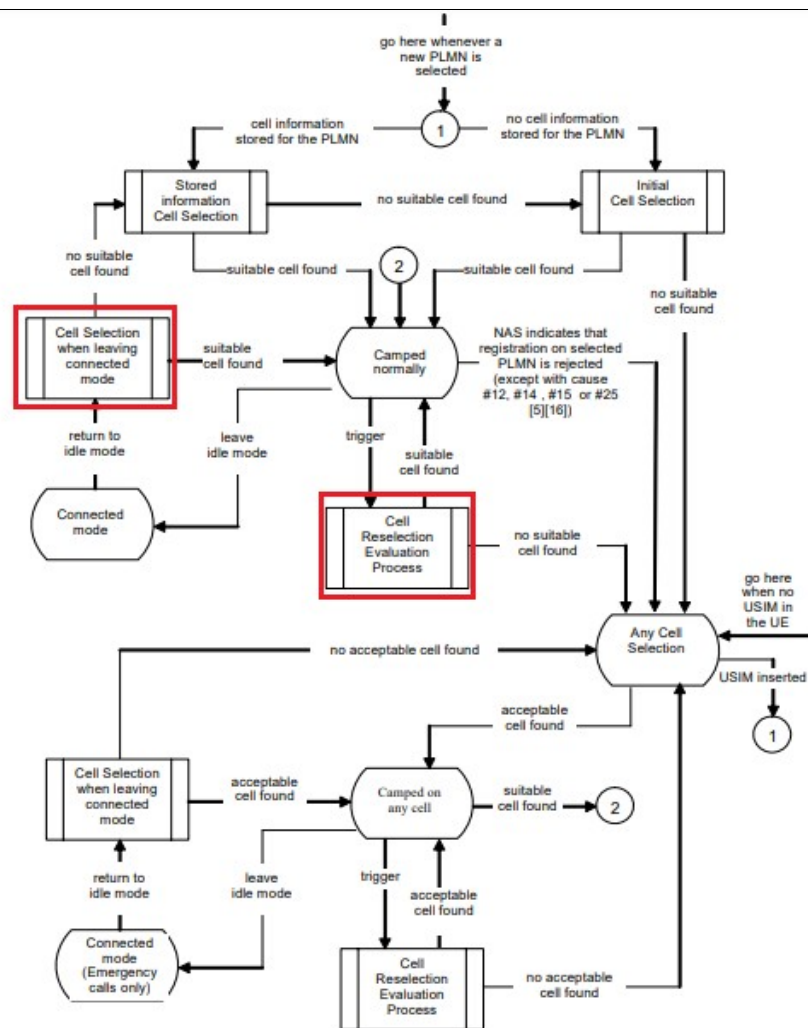
When camped on a cell, the UE shall regularly search for a better cell according to the cell reselection criteria. If a better cell is found, that cell is selected. The change of cell may imply a change of RAT. Details on performance requirements for cell reselection can be found in [10].

The NAS is informed if the cell selection and reselection results in changes in the received system information relevant for NAS.

For normal service, the UE shall camp on a suitable cell, tune to that cell's control channel(s) so that the UE can:

- Receive system information from the PLMN; and
 - receive registration area information from the PLMN, e.g., tracking area information; and
 - receive other AS and NAS Information; and
- if registered:
 - receive paging and notification messages from the PLMN; and
 - initiate transfer to connected mode.

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5.2.4.5 E-UTRAN Inter-frequency and inter-RAT Cell Reselection criteria

Criteria 1: the $S_{\text{nonServingCell},x}$ of a cell on evaluated frequency is greater than $\text{Thresh}_{x, \text{high}}$ during a time interval $\text{Treselection}_{\text{RAT}}$;

Cell reselection to a cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- A cell of a higher priority E-UTRAN frequency or inter-RAT frequency fulfils criteria 1; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

Cell reselection to a cell on an equal priority E-UTRAN frequency shall be based on ranking for Intra-frequency cell reselection as defined in sub-clause 5.2.4.6.

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- No cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency fulfills the criteria 1; and
- No cell on serving frequency or on an equal priority E-UTRAN frequency fulfills the criteria in 5.2.4.6; and
- $S_{\text{ServingCell}} < \text{Thresh}_{\text{serving, low}}$ and the $S_{\text{nonServingCell},x}$ of a cell of a lower priority E-UTRAN frequency or inter-RAT frequency is greater than $\text{Thresh}_{x, \text{low}}$ during a time interval $\text{Treselection}_{\text{RAT}}$; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

For GERAN, UTRAN, and E-UTRAN, $S_{\text{nonServingCell},x}$ is the S_{rxlev} -value of an evaluated cell. For UTRAN FDD, S_{qual} is higher than 0, as defined in [8]. For cdma2000 RATs, $S_{\text{nonServingCell},x}$ is equal to $-\text{FLOOR}(-2 \times 10 \times \log_{10} E_c/I_o)$ in units of 0.5 dB, as defined in [18], with E_c/I_o referring to the value measured from the evaluated cell.

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5.2.4 Cell Reselection evaluation process

5.2.4.1 Reselection priorities handling

Absolute priorities of different E-UTRAN frequencies or inter-RAT frequencies may be provided to the UE in the system information, in the *RRCConnectionRelease* message, or by inheriting from another RAT at inter-RAT cell (re)selection. In the case of system information, an E-UTRAN frequency or inter-RAT frequency may be listed without providing a priority (i.e. the field *cellReselectionPriority* is absent for that frequency). If priorities are provided in dedicated signalling, the UE shall ignore all the priorities provided in system information. If UE is in *camped on any cell* state, UE shall only apply the priorities provided by system information from current cell, and the UE preserves priorities provided by dedicated signalling unless specified otherwise. When the UE in *camped normally* state, has only dedicated priorities other than for the current frequency, the UE shall consider the current frequency to be the lowest priority frequency (i.e. lower than the eight network configured values). While the UE is camped on a suitable CSG cell, the UE shall always consider the current frequency to be the highest priority frequency (i.e. higher than the eight network configured values), irrespective of any other priority value allocated to this frequency. The UE shall delete priorities provided by dedicated signalling when:

- the UE enters RRC_CONNECTED state; or
- the optional validity time of dedicated priorities (T320) expires; or
- a PLMN selection is performed on request by NAS [5].

NOTE: Equal priorities between RATs are not supported.

The UE shall only perform cell reselection evaluation for E-UTRAN frequencies and inter-RAT frequencies that are given in system information and for which the UE has a priority provided.

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5.2.4.2 Measurement rules for cell re-selection

When evaluating for reselection purposes cell selection criterion or $S_{\text{ServingCell},x}$, the UE shall use parameters provided by the serving cell.

Following rules are used by the UE to limit needed measurements:

- If $S_{\text{intrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{intrasearch}}$, UE may choose to not perform intra-frequency measurements.
- If $S_{\text{ServingCell}} \leq S_{\text{intrasearch}}$, or $S_{\text{intrasearch}}$ is not sent in the serving cell UE shall perform intra-frequency measurements.
- The UE shall apply the following rules for E-UTRAN inter-frequencies and inter-RAT frequencies which are indicated in system information and for which the UE has priority provided as defined in 5.2.4.1:
 - For an E-UTRAN inter-frequency or inter-RAT frequency with a reselection priority higher than the reselection priority of the current E-UTRA frequency the UE shall perform measurements of higher priority E-UTRAN inter-frequency or inter-RAT frequencies according to [10].

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- For an E-UTRAN inter-frequency with an equal or lower reselection priority than the reselection priority of the current E-UTRA frequency and for inter-RAT frequency with lower reselection priority than the reselection priority of the current E-UTRAN frequency:
 - If $S_{\text{nonintrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{nonintrasearch}}$ UE may choose not to perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority.
 - If $S_{\text{ServingCell}} \leq S_{\text{nonintrasearch}}$ or $S_{\text{nonintrasearch}}$ is not sent in the serving cell the UE shall perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority according to [10].

Where $S_{\text{ServingCell}}$ is the S_{rxlev} -value of the serving cell.

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The cell selection criterion S is fulfilled when:

$$S_{rxlev} > 0$$

Where:

$$S_{rxlev} = Q_{rxlevmeas} - (Q_{rxlevmin} + Q_{rxlevminoffset}) - P_{compensation}$$

Where:

the signalled value $Q_{rxlevminOffset}$ is only applied when a cell is evaluated for cell selection as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]. During this periodic search for higher priority PLMN the UE may check the S criteria of a cell using parameter values stored from a different cell of this higher priority PLMN.

S_{rxlev}	Cell Selection RX level value (dB)
$Q_{rxlevmeas}$	Measured cell RX level value (RSRP).
$Q_{rxlevmin}$	Minimum required RX level in the cell (dBm)
$Q_{rxlevminoffset}$	Offset to the signalled $Q_{rxlevmin}$ taken into account in the S_{rxlev} evaluation as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]
$P_{compensation}$	$\max(P_{EMAX} - P_{PowerClass}, 0)$ (dB)
P_{EMAX}	Maximum TX power level an UE may use when transmitting on the uplink in the cell (dBm) defined as P_{EMAX} in [TS 36.101]
$P_{PowerClass}$	Maximum RF output power of the UE (dBm) according to the UE power class as defined in [TS 36.101]

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4.2.2.4 Measurements of inter-frequency E-UTRAN cells

[Editor's note: The RAN2 measurement rules for inter frequency are still to be clarified . It is assumed that the following parameter is defined : $\text{Thresh}_{\text{serv_high}}$: Threshold for the LTE serving cell when the UE initiates measurements, or increases the measurement rate (in the case of high to low priority reselection) on a different E-UTRA frequency layer. This section should be reviewed and updated once more detailed measurement rules are defined by RAN2.]

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the RSRP of the E-UTRA serving cell (or other cells on the same frequency layer) is greater than $\text{Thresh}_{\text{serv_high}}$ then

- the UE may not search for, or measure inter-frequency or inter-RAT layers of equal or lower priority.

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- the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in section 4.2.2. *Editors note: The measurement of cells that are detected in this search is still to be described.*

If the RSRP of the E-UTRA serving cell is less than or equal to $\text{Thresh}_{\text{serv_high},x}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible reselection. In this scenario, the minimum rate at which the UE is required to search for and measure such layers is not reduced.

The UE shall be able to evaluate the need for reselection to a newly detectable inter-frequency cell within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving cells assuming that $T_{\text{reselection}} = 0$. The parameter K_{carrier} is the number of E-UTRA inter-frequency carriers indicated by the serving cell. It shall be possible to evaluate the need for reselection to cells which have:

- $\text{RSRP} \geq -\text{TBD dBm}$ and $\text{Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) \geq [-3] \text{ dB}$.
- $\text{SCH Ior} > -\text{TBD dBm}$ and $\text{SCH Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) > [-3] \text{ dB}$. The UE shall measure RSRP at least every $K_{\text{carrier}} * T_{\text{measure,EUTRAN_Inter}}$ DRX cycle (see table 4.2.2.3-1) for identified inter-frequency cells. If the UE detects on a E-UTRA carrier a cell whose physical identity is indicated as not allowed for that carrier in the measurement control system information of the serving cell, the UE is not required to perform measurements on that cell.

The UE shall filter RSRP measurements of each measured inter-frequency cell using at least [2] measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by at least $[T_{\text{measure,EUTRAN_Inter}}/2]$.

The UE shall not consider a E-UTRA neighbour cell in cell reselection, if it is indicated as not allowed in the measurement control system information of the serving cell.

The filtering shall be such that the UE shall be capable of evaluating that the inter-frequency cell has met reselection criterion defined TS 36.304 within $T_{\text{evaluateFDD,Inter}}$ as specified in table 4.2.2.4-1.

Table 4.2.2.4-1 : $T_{\text{detect,EUTRAN_Inter}}$, $T_{\text{measure,EUTRAN_Inter}}$ and $T_{\text{evaluateFDD,Inter}}$

DRX cycle length [s]	$T_{\text{detect,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{measure,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{evaluateFDD,Inter}}$ [s] (number of DRX cycles)
0.32	[11.52 (36)]	[1.28 (4)]	[5.12 (16)]
0.64	[17.92 (28)]	[1.28 (2)]	[5.12 (8)]
1.28	[32(25)]	[1.28 (1)]	[6.4 (5)]
2.56	[55.88 (23)]	[2.56 (1)]	[7.68 (3)]

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said remote station for determining that a first signal falls below a threshold and that a second signal metric of the second RS-received signal is above the threshold, and that the second base station has available capacity, thereby deciding to change base stations.

The accused product practices determining that a first signal (e.g., a first RSRP value related to a first reference signal) falls below a threshold and that a second signal metric (e.g., a second RSRP value related to a second reference signal) of the second RS-received signal (e.g., a second reference signal received from a cell other than the serving cell) is above the threshold, and that the second base station has available capacity (e.g., the accused product determines that a cell other than the serving cell is suitable cell), thereby deciding to change base stations (e.g., inter-frequency cell reselection).

4.2.3 E-UTRAN FDD - FDD cell re-selection inter frequency case

4.2.3.1 Test purpose

To verify that when the neighbour cell operates on a different carrier frequency, compared to the current cell the UE is able to search and measure cells to meet the inter-frequency cell re-selection requirements.

4.2.3.2 Test applicability

This test applies to all types of E-UTRA FDD UE release 8 and forward.

4.2.3.3 Minimum conformance requirements

The cell re-selection delay shall be less than $T_{\text{evaluate,E-UTRAN_Inter}} + T_{\text{SI-EUTRA}}$ in RRC_IDLE state.

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is greater than $S_{\text{nonintrasearch}}$ then the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in TS 36.133 [4] clause 4.2.2 as $T_{\text{higher_priority_search}} = (60 * N_{\text{layers}})$ seconds, where the parameter N_{layers} is the total number of configured higher priority E-UTRA carrier frequencies.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is less than or equal to $S_{\text{nonintrasearch}}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible re-selection. In this scenario, the minimum rate at which the UE is required to search for and measure higher priority layers shall be the same as that defined below for lower or equal priority inter-frequency layers.

The UE shall be able to evaluate whether a newly detectable lower or equal priority inter-frequency cell meets the re-selection criteria defined in TS 36.304 [6] within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ (as defined in table 4.2.2.4-1 of TS 36.133 [4] clause 4.2.2.4) if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving

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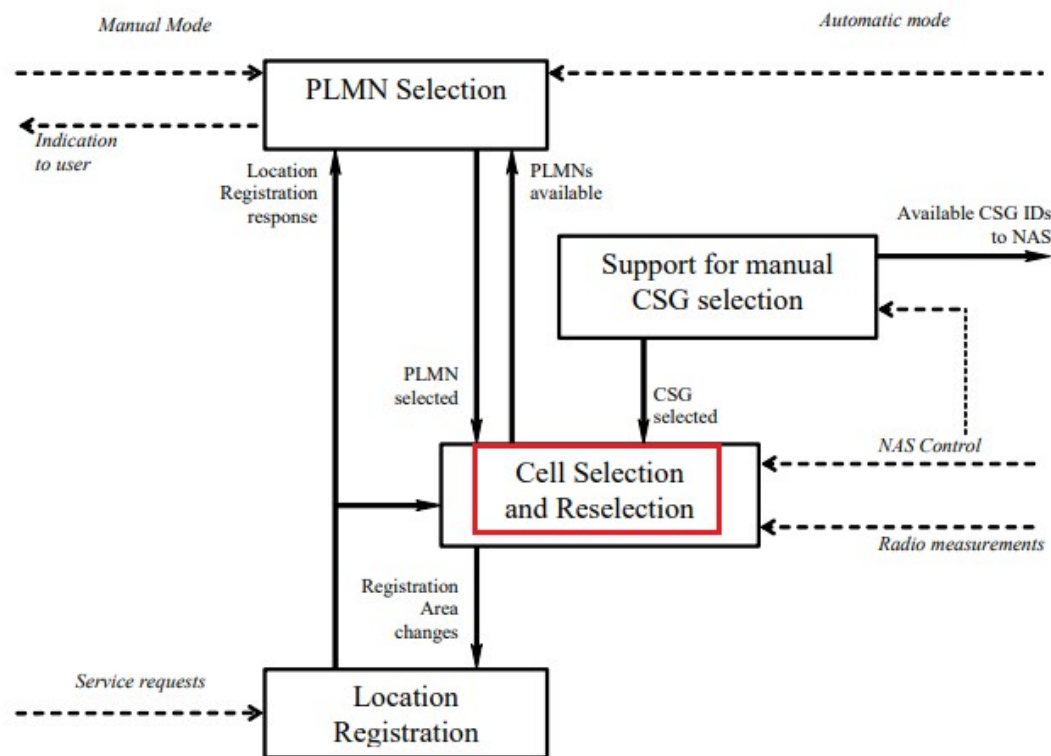


Figure 4.1-1: Overall Idle Mode process

When a UE is switched on, a public land mobile network (PLMN) is selected by NAS. For the selected PLMN, associated RAT(s) may be set [5]. The NAS shall provide a list of equivalent PLMNs, if available, that the AS shall use for cell selection and cell reselection.

With the cell selection, the UE searches for a suitable cell of the selected PLMN and chooses that cell to provide available services, further the UE shall tune to its control channel. This choosing is known as "camping on the cell".

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	<p>The UE shall, if necessary, then register its presence, by means of a NAS registration procedure, in the tracking area of the chosen cell and as outcome of a successful Location Registration the selected PLMN becomes the registered PLMN [5].</p> <p><u>If the UE finds a more suitable cell, according to the cell reselection criteria, it reselects onto that cell and camps on it.</u> If the new cell does not belong to at least one tracking area to which the UE is registered, location registration is performed.</p> <p>If necessary, the UE shall search for higher priority PLMNs at regular time intervals as described in [4] and search for a suitable cell if another PLMN has been selected by NAS.</p> <p>Search of available CSGs may be triggered by NAS to support manual CSG selection within the registered PLMN.</p> <p>If the UE loses coverage of the registered PLMN, either a new PLMN is selected automatically (automatic mode), or an indication of which PLMNs are available is given to the user, so that a manual selection can be made (manual mode).</p> <p>Registration is not performed by UEs only capable of services that need no registration.</p> <p>https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf</p>
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Cell Selection	Control cell selection for example by indicating RAT(s) associated with the selected PLMN to be used initially in the search of a cell in the cell selection. NAS is also maintaining lists of forbidden registration areas and a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) and provide these lists to AS.	<p>Perform measurements needed to support cell selection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Search for a suitable cell. The cells broadcast one or more 'PLMN identity' in the system information. Respond to NAS whether such cell is found or not.</p> <p>If associated RATs is (are) set for the PLMN, perform the search in this (these) RAT(s) and other RATs for that PLMN as specified in [5].</p> <p>If such a cell is found, the cell is selected to camp on.</p>
Cell Reselection	<p>Control cell reselection by for example, maintaining lists of forbidden registration areas.</p> <p>Maintain a list of equivalent PLMN identities and provide the list to AS.</p> <p>Maintain a list of forbidden registration areas and provide the list to AS.</p> <p>Maintain a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) to camp and provide the list to AS.</p>	<p>Perform measurements needed to support cell reselection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Change cell if a more suitable cell is found.</p>

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suitable cell:

A "suitable cell" is a cell on which the UE may camp on to obtain normal service. Such a cell shall fulfil all the following requirements.

- The cell is part of either:
 - the selected PLMN, or:
 - the registered PLMN, or:
 - a PLMN of the Equivalent PLMN list
- For a CSG cell, the CSG ID broadcast by the cell is present in the allowed CSG list associated with the PLMN for which the above condition is satisfied;

According to the latest information provided by NAS:

- The cell is not barred, see subclause 5.3.1;
- The cell is part of at least one TA that is not part of the list of "forbidden tracking areas for roaming" [4], which belongs to a PLMN that fulfils the first bullet above;
- The cell selection criteria are fulfilled, see subclause 5.2.3.2;

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5.2 Cell selection and reselection

5.2.1 Introduction

UE shall perform measurements for cell selection and reselection purposes as specified in [10].

The NAS can control the RAT(s) in which the cell selection should be performed, for instance by indicating RAT(s) associated with the selected PLMN, and by maintaining a list of forbidden registration area(s) and a list of equivalent PLMNs. The UE shall select a suitable cell based on idle mode measurements and cell selection criteria.

In order to speed up the cell selection process, stored information for several RATs may be available in the UE.

When camped on a cell, the UE shall regularly search for a better cell according to the cell reselection criteria. If a better cell is found, that cell is selected. The change of cell may imply a change of RAT. Details on performance requirements for cell reselection can be found in [10].

The NAS is informed if the cell selection and reselection results in changes in the received system information relevant for NAS.

For normal service, the UE shall camp on a suitable cell, tune to that cell's control channel(s) so that the UE can:

- Receive system information from the PLMN; and
 - receive registration area information from the PLMN, e.g., tracking area information; and
 - receive other AS and NAS Information; and
- if registered:
 - receive paging and notification messages from the PLMN; and
 - initiate transfer to connected mode.

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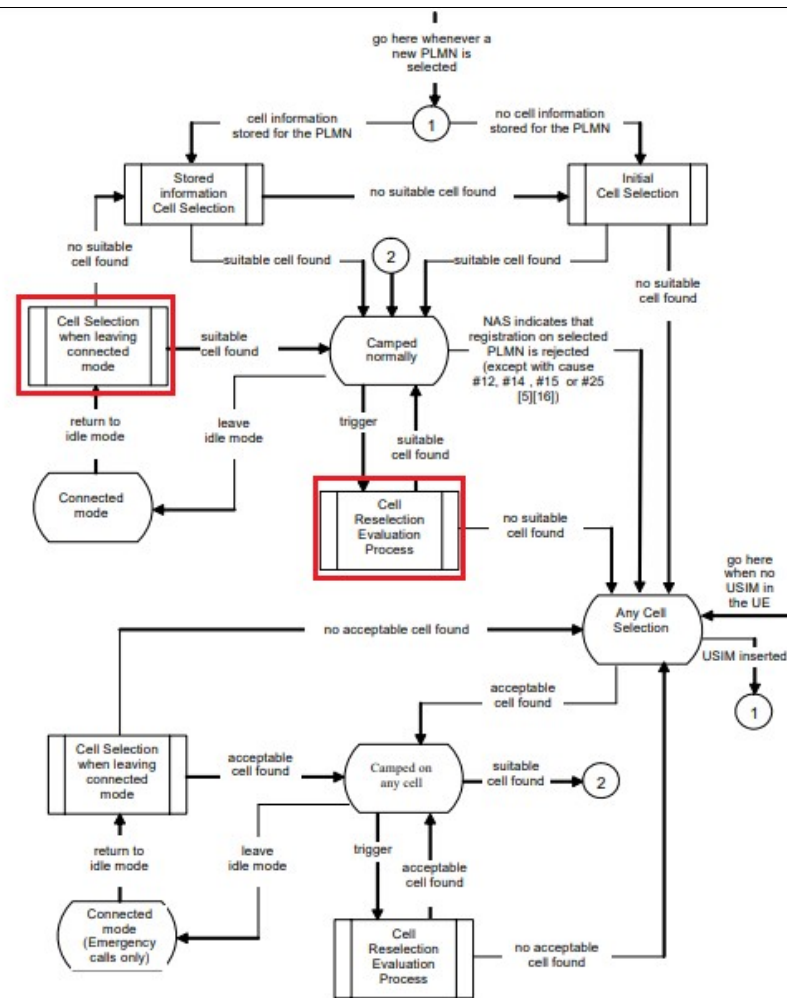


Figure 5.2.2-1: RRC_IDLE Cell Selection and Reselection

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5.2.4.5 E-UTRAN Inter-frequency and inter-RAT Cell Reselection criteria

Criteria 1: the $S_{\text{nonServingCell},x}$ of a cell on evaluated frequency is greater than $\text{Thresh}_{x, \text{high}}$ during a time interval $\text{Treselection}_{\text{RAT}}$;

Cell reselection to a cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- A cell of a higher priority E-UTRAN frequency or inter-RAT frequency fulfils criteria 1; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

Cell reselection to a cell on an equal priority E-UTRAN frequency shall be based on ranking for Intra-frequency cell reselection as defined in sub-clause 5.2.4.6.

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- No cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency fulfills the criteria 1; and
- No cell on serving frequency or on an equal priority E-UTRAN frequency fulfills the criteria in 5.2.4.6; and
- $S_{\text{ServingCell}} < \text{Thresh}_{\text{serving, low}}$ and the $S_{\text{nonServingCell},x}$ of a cell of a lower priority E-UTRAN frequency or inter-RAT frequency is greater than $\text{Thresh}_{x, \text{low}}$ during a time interval $\text{Treselection}_{\text{RAT}}$; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

For GERAN, UTRAN, and E-UTRAN, $S_{\text{nonServingCell},x}$ is the S_{rxlev} -value of an evaluated cell. For UTRAN FDD, S_{qual} is higher than 0, as defined in [8]. For cdma2000 RATs, $S_{\text{nonServingCell},x}$ is equal to $-\text{FLOOR}(-2 \times 10 \times \log_{10} E_c/I_o)$ in units of 0.5 dB, as defined in [18], with E_c/I_o referring to the value measured from the evaluated cell.

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5.2.4 Cell Reselection evaluation process

5.2.4.1 Reselection priorities handling

Absolute priorities of different E-UTRAN frequencies or inter-RAT frequencies may be provided to the UE in the system information, in the *RRCConnectionRelease* message, or by inheriting from another RAT at inter-RAT cell (re)selection. In the case of system information, an E-UTRAN frequency or inter-RAT frequency may be listed without providing a priority (i.e. the field *cellReselectionPriority* is absent for that frequency). If priorities are provided in dedicated signalling, the UE shall ignore all the priorities provided in system information. If UE is in *camped on any cell* state, UE shall only apply the priorities provided by system information from current cell, and the UE preserves priorities provided by dedicated signalling unless specified otherwise. When the UE in *camped normally* state, has only dedicated priorities other than for the current frequency, the UE shall consider the current frequency to be the lowest priority frequency (i.e. lower than the eight network configured values). While the UE is camped on a suitable CSG cell, the UE shall always consider the current frequency to be the highest priority frequency (i.e. higher than the eight network configured values), irrespective of any other priority value allocated to this frequency. The UE shall delete priorities provided by dedicated signalling when:

- the UE enters RRC_CONNECTED state; or
- the optional validity time of dedicated priorities (T320) expires; or
- a PLMN selection is performed on request by NAS [5].

NOTE: Equal priorities between RATs are not supported.

The UE shall only perform cell reselection evaluation for E-UTRAN frequencies and inter-RAT frequencies that are given in system information and for which the UE has a priority provided.

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5.2.4.2 Measurement rules for cell re-selection

When evaluating for reselection purposes cell selection criterion or $S_{\text{ServingCell},x}$, the UE shall use parameters provided by the serving cell.

Following rules are used by the UE to limit needed measurements:

- If $S_{\text{intrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{intrasearch}}$, UE may choose to not perform intra-frequency measurements.
- If $S_{\text{ServingCell}} \leq S_{\text{intrasearch}}$, or $S_{\text{intrasearch}}$ is not sent in the serving cell UE shall perform intra-frequency measurements.
- The UE shall apply the following rules for E-UTRAN inter-frequencies and inter-RAT frequencies which are indicated in system information and for which the UE has priority provided as defined in 5.2.4.1:
 - For an E-UTRAN inter-frequency or inter-RAT frequency with a reselection priority higher than the reselection priority of the current E-UTRA frequency the UE shall perform measurements of higher priority E-UTRAN inter-frequency or inter-RAT frequencies according to [10].

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- For an E-UTRAN inter-frequency with an equal or lower reselection priority than the reselection priority of the current E-UTRA frequency and for inter-RAT frequency with lower reselection priority than the reselection priority of the current E-UTRAN frequency:
 - If $S_{\text{nonintrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{nonintrasearch}}$ UE may choose not to perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority.
 - If $S_{\text{ServingCell}} \leq S_{\text{nonintrasearch}}$ or $S_{\text{nonintrasearch}}$ is not sent in the serving cell the UE shall perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority according to [10].

Where $S_{\text{ServingCell}}$ is the S_{rxlev} -value of the serving cell.

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The cell selection criterion S is fulfilled when:

$$S_{rxlev} > 0$$

Where:

$$S_{rxlev} = Q_{rxlevmeas} - (Q_{rxlevmin} + Q_{rxlevminoffset}) - P_{compensation}$$

Where:

the signalled value $Q_{rxlevminOffset}$ is only applied when a cell is evaluated for cell selection as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]. During this periodic search for higher priority PLMN the UE may check the S criteria of a cell using parameter values stored from a different cell of this higher priority PLMN.

S_{rxlev}	Cell Selection RX level value (dB)
$Q_{rxlevmeas}$	Measured cell RX level value (RSRP).
$Q_{rxlevmin}$	Minimum required RX level in the cell (dBm)
$Q_{rxlevminoffset}$	Offset to the signalled $Q_{rxlevmin}$ taken into account in the S_{rxlev} evaluation as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]
$P_{compensation}$	$\max(P_{EMAX} - P_{PowerClass}, 0)$ (dB)
P_{EMAX}	Maximum TX power level an UE may use when transmitting on the uplink in the cell (dBm) defined as P_{EMAX} in [TS 36.101]
$P_{PowerClass}$	Maximum RF output power of the UE (dBm) according to the UE power class as defined in [TS 36.101]

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4.2.2.4 Measurements of inter-frequency E-UTRAN cells

[Editor's note: The RAN2 measurement rules for inter frequency are still to be clarified . It is assumed that the following parameter is defined : $\text{Thresh}_{\text{serv_high}}$: Threshold for the LTE serving cell when the UE initiates measurements, or increases the measurement rate (in the case of high to low priority reselection) on a different E-UTRA frequency layer. This section should be reviewed and updated once more detailed measurement rules are defined by RAN2.]

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the RSRP of the E-UTRA serving cell (or other cells on the same frequency layer) is greater than $\text{Thresh}_{\text{serv_high}}$ then

- the UE may not search for, or measure inter-frequency or inter-RAT layers of equal or lower priority.

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- the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in section 4.2.2. *Editors note: The measurement of cells that are detected in this search is still to be described.*

If the RSRP of the E-UTRA serving cell is less than or equal to $\text{Thresh}_{\text{serving_high},x}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible reselection. In this scenario, the minimum rate at which the UE is required to search for and measure such layers is not reduced.

The UE shall be able to evaluate the need for reselection to a newly detectable inter-frequency cell within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving cells assuming that $T_{\text{reselection}} = 0$. The parameter K_{carrier} is the number of E-UTRA inter-frequency carriers indicated by the serving cell. It shall be possible to evaluate the need for reselection to cells which have:

- $\text{RSRP} \geq -\text{TBD dBm}$ and $\text{Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) \geq [-3] \text{ dB}$.
- $\text{SCH Ior} > -\text{TBD dBm}$ and $\text{SCH Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) > [-3] \text{ dB}$. The UE shall measure RSRP at least every $K_{\text{carrier}} * T_{\text{measure,EUTRAN_Inter}}$ DRX cycle (see table 4.2.2.3-1) for identified inter-frequency cells. If the UE detects on a E-UTRA carrier a cell whose physical identity is indicated as not allowed for that carrier in the measurement control system information of the serving cell, the UE is not required to perform measurements on that cell.

The UE shall filter RSRP measurements of each measured inter-frequency cell using at least [2] measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by at least $[T_{\text{measure,EUTRAN_Inter}}/2]$.

The UE shall not consider a E-UTRA neighbour cell in cell reselection, if it is indicated as not allowed in the measurement control system information of the serving cell.

The filtering shall be such that the UE shall be capable of evaluating that the inter-frequency cell has met reselection criterion defined TS 36.304 within $T_{\text{evaluateFDD,Inter}}$ as specified in table 4.2.2.4-1.

Table 4.2.2.4-1 : $T_{\text{detect,EUTRAN_Inter}}$, $T_{\text{measure,EUTRAN_Inter}}$ and $T_{\text{evaluateFDD,Inter}}$

DRX cycle length [s]	$T_{\text{detect,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{measure,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{evaluateFDD,Inter}}$ [s] (number of DRX cycles)
0.32	[11.52 (36)]	[1.28 (4)]	[5.12 (16)]
0.64	[17.92 (28)]	[1.28 (2)]	[5.12 (8)]
1.28	[32(25)]	[1.28 (1)]	[6.4 (5)]
2.56	[55.88 (23)]	[2.56 (1)]	[7.68 (3)]

https://www.etsi.org/deliver/etsi_ts/136100_136199/136133/08.02.00_60/ts_136133v080200p.pdf

	<p>3GPP TS 36.300 version 8.7.0 Release 8 43 ETSI TS 136 300 V8.7.0 (2009-01)</p> <ul style="list-style-type: none"> - The UE searches the E-UTRA frequency bands and for each carrier frequency identifies the strongest cell. It reads cell system information broadcast to identify its PLMN(s): - The UE may search each carrier in turn ('initial cell selection') or make use of stored information to shorten the search ('stored information cell selection'). - The UE seeks to identify a suitable cell; if it is not able to identify a suitable cell it seeks to identify an acceptable cell. When a suitable cell is found or if only an acceptable cell is found it camps on that cell and commence the cell reselection procedure: - A suitable cell is one for which the measured cell attributes satisfy the cell selection criteria; the cell PLMN is the selected PLMN, registered or an equivalent PLMN; the cell is not barred or reserved and the cell is not part of a tracking area which is in the list of 'forbidden tracking areas for roaming'; - An acceptable cell is one for which the measured cell attributes satisfy the cell selection criteria and the cell is not barred; <p>https://www.etsi.org/deliver/etsi_ts/136300_136399/136300/08.07.00_60/ts_136300v080700p.pdf</p>
10. An improvement to a spread spectrum system comprising:	<p>A system utilized by the accused product is an improvement to a spread-spectrum system.</p> <p>The accused product has LTE-FDD and 802.11a/b/n capabilities.</p>



Sentrius™ RG191+LTE Gateways

LoRaWAN-enabled Gateway with
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FLEXIBLE MULTI WIRELESS GATEWAY
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- **LTE CAT 1 M.2 card** – 3GPP Release 11, Bands B2/4/5/12/13 supported – North America Region
- **Full Linux operating system** – Kernel v4.x running on Atmel A5 Core @ 536 MHz
- **Multiple interfaces** such as LTE CAT 1, LoRaWAN, Wi-Fi 802.11a/b/g/n and Ethernet
- **8-Channel LoRaWAN support** with up to +27 dBm max TX power
- **Comprehensive Certifications** for FCC, IC & PTCRB and co-located radio certification
- **Industrial temperature range** (-30° to +70° C)
- **Advanced deployment tools** including intuitive web-based configuration and integrated presets for multiple external LoRa Network Server vendors
- **Enterprise-grade security** built on our years of experience in wireless
- **Industry-leading support** works directly with our engineers to help deploy your design

<https://www.lairdconnect.com/documentation/product-brief-sentrius-rg191lte>

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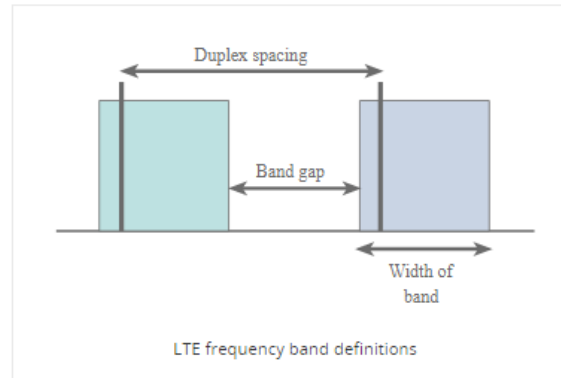
As shown below, the accused product works on LTE frequency band number 2,4,5,12,13 among others. These band numbers correspond to LTE FDD as outlined below.

- **LTE CAT 1 M.2 card** – 3GPP Release 11, Bands B2/4/5/12/13 supported – North America Region
- **Full Linux operating system** – Kernel v4.x running on Atmel A5 Core @ 536 MHz
- **Multiple interfaces** such as LTE CAT 1, LoRaWAN, Wi-Fi 802.11a/b/g/n and Ethernet
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FDD LTE frequency band allocations

There is a large number of allocations or radio spectrum that has been reserved for FDD, frequency division duplex, LTE use.



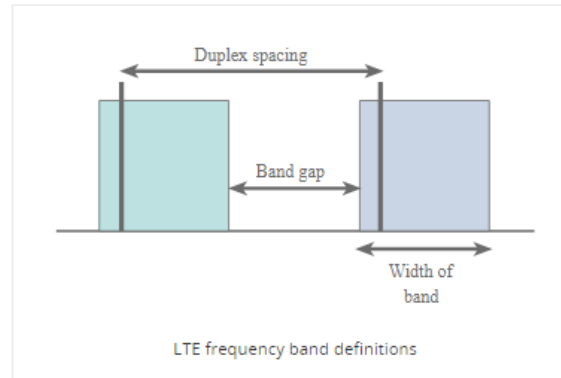
<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/frequency-bands-channels-spectrum.php>

FDD LTE BANDS & FREQUENCIES					
LTE BAND NUMBER	UPLINK (MHZ)	DOWNLINK (MHZ)	WIDTH OF BAND (MHZ)	DUPLEX SPACING (MHZ)	BAND GAP (MHZ)
1	1920 - 1980	2110 - 2170	60	190	130
2	1850 - 1910	1930 - 1990	60	80	20
3	1710 - 1785	1805 - 1880	75	95	20
4	1710 - 1755	2110 - 2155	45	400	355
5	824 - 849	869 - 894	25	45	20
6	830 - 840	875 - 885	10	35	25
7	2500 - 2570	2620 - 2690	70	120	50
8	880 - 915	925 - 960	35	45	10
9	1749.9 - 1784.9	1844.9 - 1879.9	35	95	60
10	1710 - 1770	2110 - 2170	60	400	340
11	1427.9 - 1452.9	1475.9 - 1500.9	20	48	28
12	698 - 716	728 - 746	18	30	12
13	777 - 787	746 - 756	10	-31	41
14	788 - 798	758 - 768	10	-30	40
15	1900 - 1920	2600 - 2620	20	700	680
16	2010 - 2025	2585 - 2600	15	575	560
17	704 - 716	734 - 746	12	30	18
18	815 - 830	860 - 875	15	45	30
19	830 - 845	875 - 890	15	45	30
20	832 - 862	791 - 821	30	-41	71
21	1447.9 - 1462.9	1495.5 - 1510.9	15	48	33

<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/frequency-bands-channels-spectrum.php>

FDD LTE frequency band allocations

There is a large number of allocations or radio spectrum that has been reserved for FDD, frequency division duplex, LTE use.



<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/frequency-bands-channels-spectrum.php>

The Evolved Packet System (EPS) is purely IP based. Both real time services and datacom services will be carried by the IP protocol. The IP address is allocated when the mobile is switched on and released when switched off.

The new access solution, LTE, is based on OFDMA (Orthogonal Frequency Division Multiple Access) and in combination with higher order modulation (up to 64QAM), large bandwidths (up to 20 MHz) and spatial multiplexing in the downlink (up to 4x4) high data rates can be achieved. The highest theoretical peak data rate on the transport channel is 75 Mbps in the uplink, and in the downlink, using spatial multiplexing, the rate can be as high as 300 Mbps.

The LTE access network is simply a network of base stations, evolved NodeB (eNB), generating a flat architecture (figure 2). There is no centralized intelligent controller, and the eNBs are normally inter-connected via the X2-interface and towards the core network by the S1-interface (figure 2). The reason for distributing the intelligence amongst the base-stations in LTE is to speed up the connection set-up and reduce the time required for a handover. For an end-user the connection set-up time for a real time data session is in many cases crucial, especially in on-line gaming. The time for a handover is essential for real-time services where end-users tend to end calls if the handover takes too long.

<https://www.3gpp.org/technologies/keywords-acronyms/98-lte>

To achieve high radio spectral efficiency as well as enable efficient scheduling in both time and frequency domain, a multicarrier approach for multiple access was chosen by 3GPP. For the downlink, OFDMA (Orthogonal Frequency Division Multiple Access) was selected and for the uplink SC-FDMA (Single Carrier - Frequency Division Multiple Access) also known as DFT (Discrete Fourier Transform) spread OFDMA (figure 3).

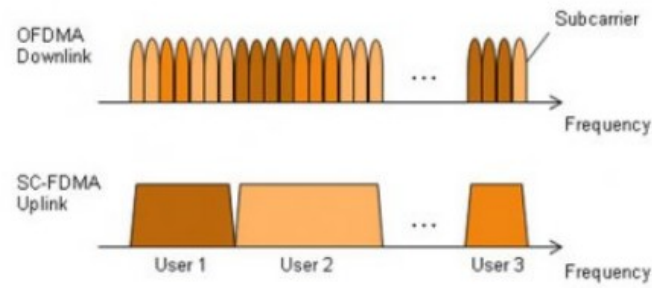


Figure 3 OFDMA and SC-FDMA

OFDM is a multicarrier technology subdividing the available bandwidth into a multitude of mutual orthogonal narrowband subcarriers. In OFDMA these subcarriers can be shared between multiple users. The OFDMA solution leads to high Peak-to-Average Power Ratio (PAPR) requiring expensive power amplifiers with high requirements on linearity, increasing the power consumption for the sender. This is no problem in the eNB, but would lead to very expensive handsets. Hence a different solution was selected for the UL. As illustrated in figure 3, the SC-FDMA solution generates a signal with single carrier characteristics, hence with a low PAPR.

<https://www.3gpp.org/technologies/keywords-acronyms/98-lte>

If we then examine the Fourier transform of our functions given in equation (8.6), we obtain a sinc function of pseudo-period T_s , which means that in the frequency domain subcarriers are spaced exactly such that the peak of the next one corresponds to the previous one's first zero – see figure 8.3.

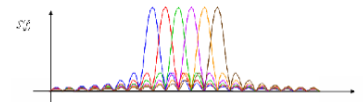


Figure 8.3: OFDM subcarrier spacing.

The overall envelope looks a bit like a spread spectrum signal, and may be tapered further to reduce out of band spectral power density.

<http://morse.colorado.edu/~tlen5510/text/classwebch8.html>

Since the subcarriers that carry data are transmitted at a low rate, with higher symbol time, OFDM is more resilient to multipath effects. Therefore, it is more suitable for wide-area non-line of sight wireless access technology.

Also, using overlapping orthogonal subcarriers without guard bands makes it more efficient than the FDM scheme in terms of bits per Hertz. OFDM is a spread-spectrum technology in which energy generated at a particular bandwidth is spread across a wider bandwidth making it more resilient to interference and “jamming”.

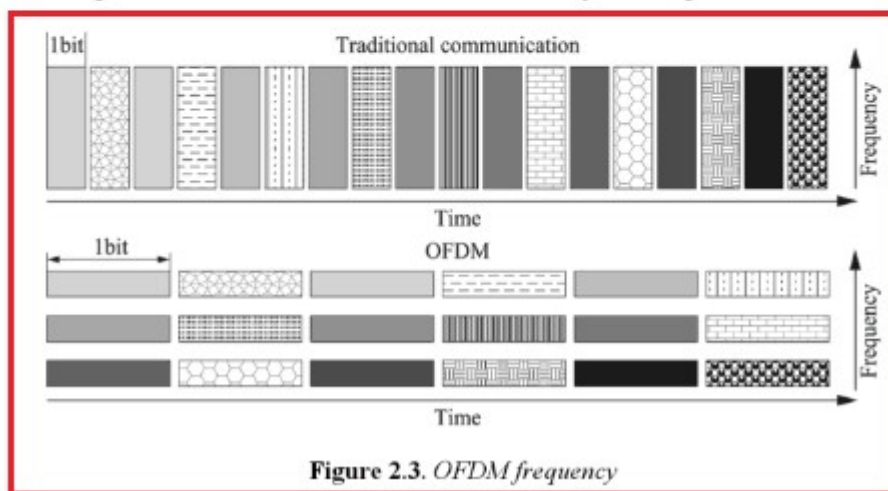


Figure 2.3. OFDM frequency

Source: "LTE Standards" By Jean-Gabriel Rémy, Charlotte Letamendia
<https://onlinelibrary.wiley.com/doi/book/10.1002/9781119043508>

a frequency division duplex (FDD), distributed network;

The system utilized by the accused product comprises a frequency division duplex (FDD), distributed network (e.g., a network comprising the accused product with 802.11 b/g/n capability, another product/device to which the accused product can communicate via 802.11a/b/n communication, and several base stations).

To enable possible deployment around the world, supporting as many regulatory requirements as possible, LTE is developed for a number of frequency bands – E-UTRA operating bands- currently ranging from 700 MHz up to 2.7GHz. The available bandwidths are also flexible starting with 1.4 MHz up to 20 MHz. LTE is developed to support both the time division duplex technology (TDD) as well as frequency division duplex (FDD). In R8 there are 15 bands specified for FDD and eight bands for TDD. In R9 four bands were added for FDD. Also added in R9 were for example Multimedia Broadcast Multicast Service (MBMS), and Home eNB (HeNB), see figure 4. MBMS is used to provide broadcast information to all users, for example advertisement, and multicast to a closed group subscribing to a specific service, e.g. streaming TV. HeNBs are introduced mainly to provide coverage indoors, in homes or offices. The HeNB is a low power eNB that will be used in small cells – femto cells. Normally it will be owned by the customer, deployed without any network planning and connected to the operators EPC (Evolved Packet Core).

<https://www.3gpp.org/technologies/keywords-acronyms/98-lte>

LTE can utilise both FDD - frequency division duplex and TDD - time division duplex, often referred to as TD-LTE.

Both forms of duplex, FDD and TDD have their advantages and the areas where their deployment is advantageous.

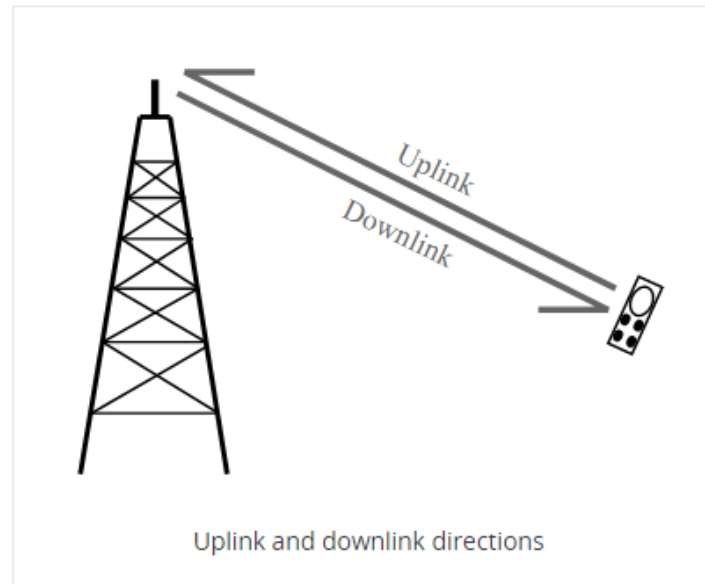
For most normal LTE deployments the frequency division duplex, FDD is used, and paired spectrum with equal bandwidth in up and downlinks is utilised.

LTE FDD using the paired spectrum was considered to be the migration path for the UMTS 3G services which typically utilised paired spectrum.

However there was considerable development placed on the time division duplex form of LTE: TDD LTE or TD-LTE which was seen as the upgrade path for TD-SCDMA that was developed and introduced by the Chinese as a 3G technology.

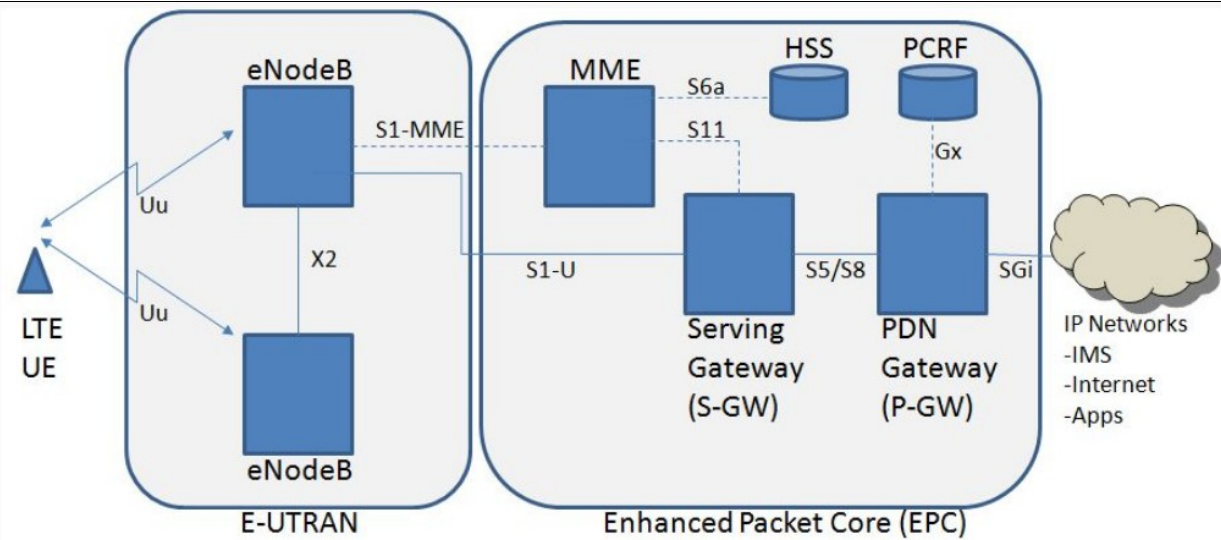
<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/tdd-fdd-td-lte-duplex-schemes.php>

- **Uplink:** the transmission from the UE or user equipment to the eNodeB or base station.
- **Downlink** the transmission from the eNodeB or base station to the UE or user equipment.

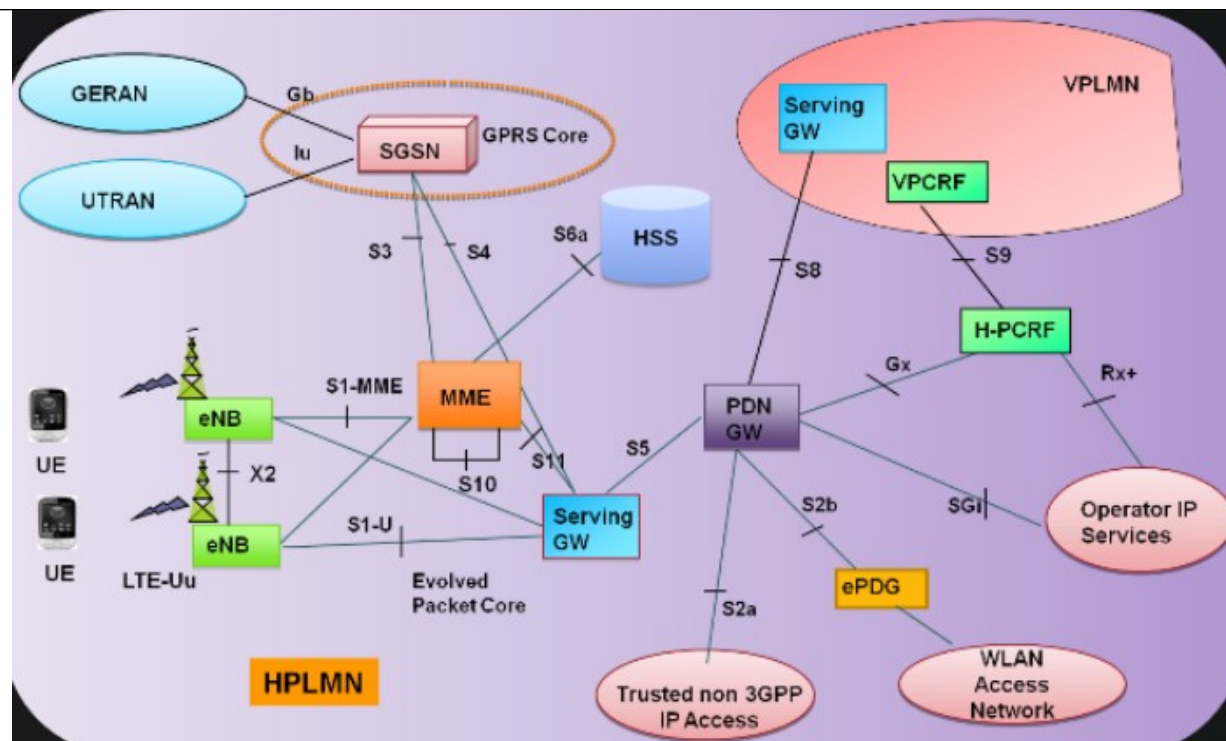


In order to be able to be able to transmit in both directions, a user equipment or base station must have a duplex scheme. There are two forms of duplex that are commonly used, namely FDD, frequency division duplex and TDD time division duplex..

<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/tdd-fdd-td-lte-duplex-schemes.php>



<https://www.rcrwireless.com/20140509/evolved-packet-core-epc/lte-network-diagram#prettyPhoto/5/>



<http://hershenq.blogspot.com/2012/03/architecture-of-lte-network-and-working.html>

first base station (BS) means, located in, and part of, the FDD distributed network, for transmitting, using radio waves, a first BS-packet signal spread at a first frequency;

The system utilized by the accused product comprises a first base station (BS) (e.g., a serving cell for a user equipment), located in, and part of, the FDD distributed network, for transmitting, using radio waves, a first BS-packet signal (e.g., a reference signal) at a first frequency (e.g., a first frequency).

4.2.3 E-UTRAN FDD - FDD cell re-selection inter frequency case

4.2.3.1 Test purpose

To verify that when the neighbour cell operates on a different carrier frequency, compared to the current cell the UE is able to search and measure cells to meet the inter-frequency cell re-selection requirements.

4.2.3.2 Test applicability

This test applies to all types of E-UTRA FDD UE release 8 and forward.

4.2.3.3 Minimum conformance requirements

The cell re-selection delay shall be less than $T_{\text{evaluate,E-UTRAN_Inter}} + T_{\text{SI-EUTRA}}$ in RRC_IDLE state.

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is greater than $S_{\text{nonintrasearch}}$ then the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher priority search}}$ where $T_{\text{higher priority search}}$ is described in TS 36.133 [4] clause 4.2.2 as $T_{\text{higher priority search}} = (60 * N_{\text{layers}})$ seconds, where the parameter N_{layers} is the total number of configured higher priority E-UTRA carrier frequencies.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is less than or equal to $S_{\text{nonintrasearch}}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible re-selection. In this scenario, the minimum rate at which the UE is required to search for and measure higher priority layers shall be the same as that defined below for lower or equal priority inter-frequency layers.

The UE shall be able to evaluate whether a newly detectable lower or equal priority inter-frequency cell meets the re-selection criteria defined in TS 36.304 [6] within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ (as defined in table 4.2.2.4-1 of TS 36.133 [4] clause 4.2.2.4) if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving

https://www.etsi.org/deliver/etsi_ts/136500_136599/13652103/10.00.00_60/ts_13652103v100000p.pdf

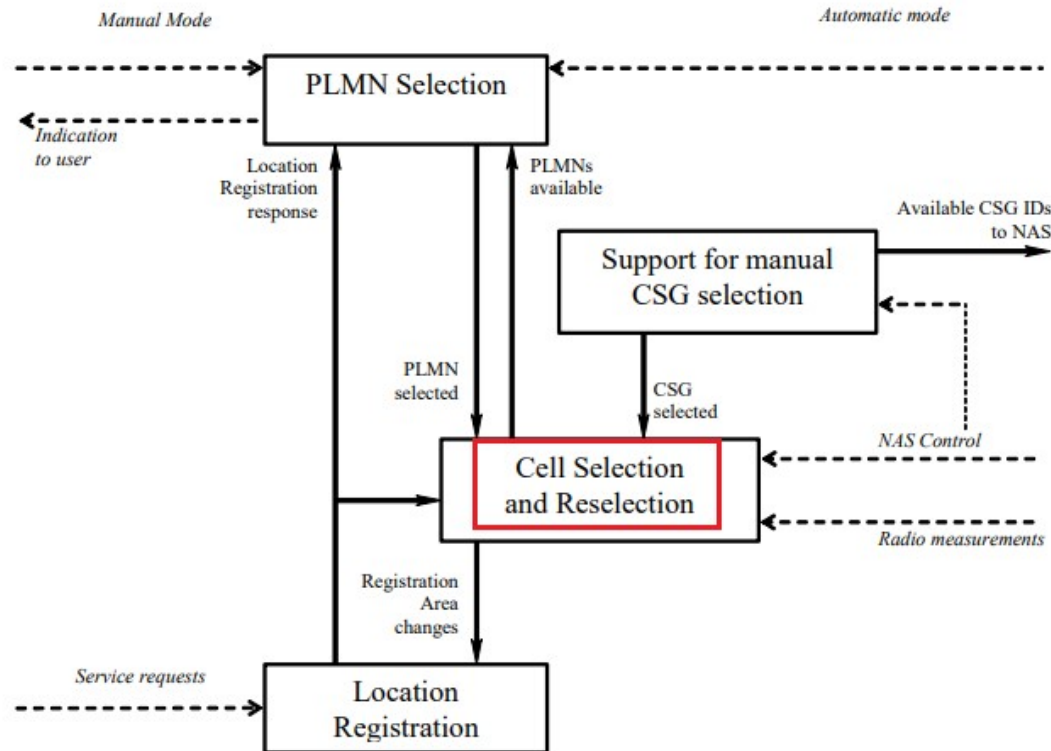


Figure 4.1-1: Overall Idle Mode process

When a UE is switched on, a public land mobile network (PLMN) is selected by NAS. For the selected PLMN, associated RAT(s) may be set [5]. The NAS shall provide a list of equivalent PLMNs, if available, that the AS shall use for cell selection and cell reselection.

With the cell selection, the UE searches for a suitable cell of the selected PLMN and chooses that cell to provide available services, further the UE shall tune to its control channel. This choosing is known as "camping on the cell".

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

	<p>The UE shall, if necessary, then register its presence, by means of a NAS registration procedure, in the tracking area of the chosen cell and as outcome of a successful Location Registration the selected PLMN becomes the registered PLMN [5].</p> <p><u>If the UE finds a more suitable cell, according to the cell reselection criteria, it reselects onto that cell and camps on it. If the new cell does not belong to at least one tracking area to which the UE is registered, location registration is performed.</u></p> <p>If necessary, the UE shall search for higher priority PLMNs at regular time intervals as described in [4] and search for a suitable cell if another PLMN has been selected by NAS.</p> <p>Search of available CSGs may be triggered by NAS to support manual CSG selection within the registered PLMN.</p> <p>If the UE loses coverage of the registered PLMN, either a new PLMN is selected automatically (automatic mode), or an indication of which PLMNs are available is given to the user, so that a manual selection can be made (manual mode).</p> <p>Registration is not performed by UEs only capable of services that need no registration.</p> <p>https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf</p>
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	Cell Selection	Control cell selection for example by indicating RAT(s) associated with the selected PLMN to be used initially in the search of a cell in the cell selection. NAS is also maintaining lists of forbidden registration areas and a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) and provide these lists to AS.	<p>Perform measurements needed to support cell selection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Search for a suitable cell. The cells broadcast one or more 'PLMN identity' in the system information. Respond to NAS whether such cell is found or not.</p> <p>If associated RATs is (are) set for the PLMN, perform the search in this (these) RAT(s) and other RATs for that PLMN as specified in [5].</p> <p>If such a cell is found, the cell is selected to camp on.</p>
	Cell Reselection	<p>Control cell reselection by for example, maintaining lists of forbidden registration areas.</p> <p>Maintain a list of equivalent PLMN identities and provide the list to AS.</p> <p>Maintain a list of forbidden registration areas and provide the list to AS.</p> <p>Maintain a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) to camp and provide the list to AS.</p>	<p>Perform measurements needed to support cell reselection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Change cell if a more suitable cell is found.</p>

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

suitable cell:

A "suitable cell" is a cell on which the UE may camp on to obtain normal service. Such a cell shall fulfil all the following requirements.

- The cell is part of either:
 - the selected PLMN, or:
 - the registered PLMN, or:
 - a PLMN of the Equivalent PLMN list
- For a CSG cell, the CSG ID broadcast by the cell is present in the allowed CSG list associated with the PLMN for which the above condition is satisfied;

According to the latest information provided by NAS:

- The cell is not barred, see subclause 5.3.1;
- The cell is part of at least one TA that is not part of the list of "forbidden tracking areas for roaming" [4], which belongs to a PLMN that fulfils the first bullet above;
- The cell selection criteria are fulfilled, see subclause 5.2.3.2;

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

5.2 Cell selection and reselection

5.2.1 Introduction

UE shall perform measurements for cell selection and reselection purposes as specified in [10].

The NAS can control the RAT(s) in which the cell selection should be performed, for instance by indicating RAT(s) associated with the selected PLMN, and by maintaining a list of forbidden registration area(s) and a list of equivalent PLMNs. The UE shall select a suitable cell based on idle mode measurements and cell selection criteria.

In order to speed up the cell selection process, stored information for several RATs may be available in the UE.

When camped on a cell, the UE shall regularly search for a better cell according to the cell reselection criteria. If a better cell is found, that cell is selected. The change of cell may imply a change of RAT. Details on performance requirements for cell reselection can be found in [10].

The NAS is informed if the cell selection and reselection results in changes in the received system information relevant for NAS.

For normal service, the UE shall camp on a suitable cell, tune to that cell's control channel(s) so that the UE can:

- Receive system information from the PLMN; and
 - receive registration area information from the PLMN, e.g., tracking area information; and
 - receive other AS and NAS Information; and
- if registered:
 - receive paging and notification messages from the PLMN; and
 - initiate transfer to connected mode.

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

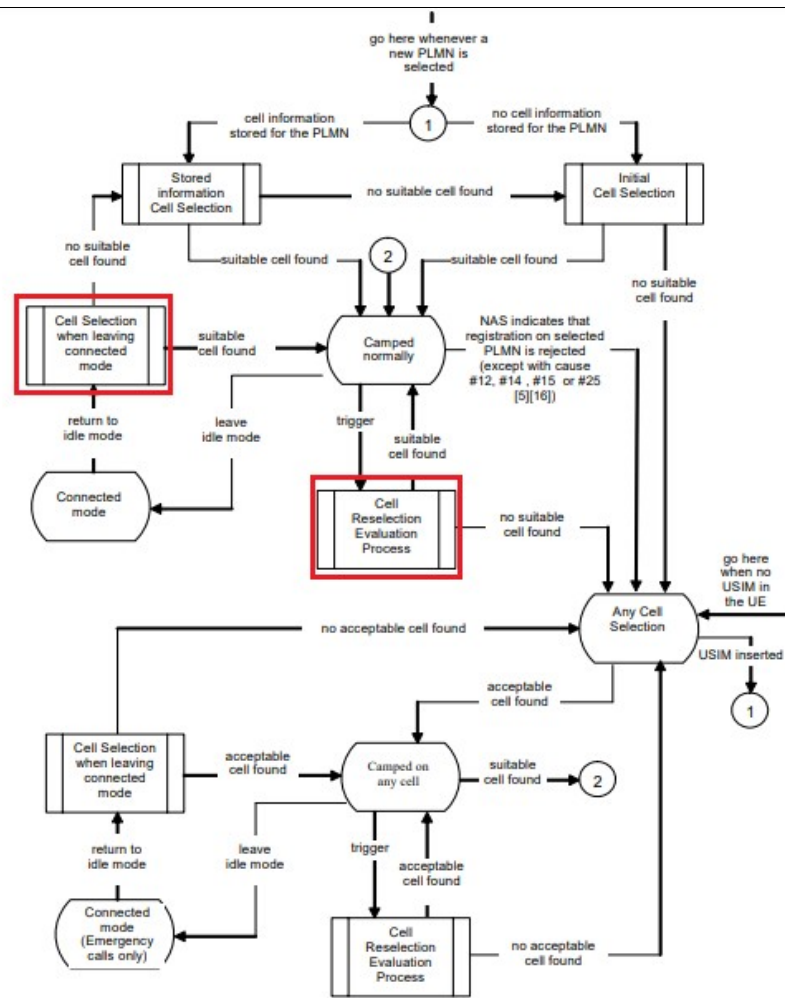


Figure 5.2.2-1: RRC_IDLE Cell Selection and Reselection

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

5.2.4.5 E-UTRAN Inter-frequency and inter-RAT Cell Reselection criteria

Criteria 1: the $S_{\text{nonServingCell},x}$ of a cell on evaluated frequency is greater than $\text{Thresh}_{x, \text{high}}$ during a time interval $\text{Treselection}_{\text{RAT}}$;

Cell reselection to a cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- A cell of a higher priority E-UTRAN frequency or inter-RAT frequency fulfils criteria 1; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

Cell reselection to a cell on an equal priority E-UTRAN frequency shall be based on ranking for Intra-frequency cell reselection as defined in sub-clause 5.2.4.6.

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- No cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency fulfills the criteria 1; and
- No cell on serving frequency or on an equal priority E-UTRAN frequency fulfills the criteria in 5.2.4.6; and
- $S_{\text{ServingCell}} < \text{Thresh}_{\text{serving}, \text{low}}$ and the $S_{\text{nonServingCell},x}$ of a cell of a lower priority E-UTRAN frequency or inter-RAT frequency is greater than $\text{Thresh}_{x, \text{low}}$ during a time interval $\text{Treselection}_{\text{RAT}}$; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

For GERAN, UTRAN, and E-UTRAN, $S_{\text{nonServingCell},x}$ is the S_{rxlev} -value of an evaluated cell. For UTRAN FDD, S_{qual} is higher than 0, as defined in [8]. For cdma2000 RATs, $S_{\text{nonServingCell},x}$ is equal to $-\text{FLOOR}(-2 \times 10 \times \log_{10} E_c/I_o)$ in units of 0.5 dB, as defined in [18], with E_c/I_o referring to the value measured from the evaluated cell.

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

5.2.4 Cell Reselection evaluation process

5.2.4.1 Reselection priorities handling

Absolute priorities of different E-UTRAN frequencies or inter-RAT frequencies may be provided to the UE in the system information, in the *RRCConnectionRelease* message, or by inheriting from another RAT at inter-RAT cell (re)selection. In the case of system information, an E-UTRAN frequency or inter-RAT frequency may be listed without providing a priority (i.e. the field *cellReselectionPriority* is absent for that frequency). If priorities are provided in dedicated signalling, the UE shall ignore all the priorities provided in system information. If UE is in *camped on any cell* state, UE shall only apply the priorities provided by system information from current cell, and the UE preserves priorities provided by dedicated signalling unless specified otherwise. When the UE in *camped normally* state, has only dedicated priorities other than for the current frequency, the UE shall consider the current frequency to be the lowest priority frequency (i.e. lower than the eight network configured values). While the UE is camped on a suitable CSG cell, the UE shall always consider the current frequency to be the highest priority frequency (i.e. higher than the eight network configured values), irrespective of any other priority value allocated to this frequency. The UE shall delete priorities provided by dedicated signalling when:

- the UE enters RRC_CONNECTED state; or
- the optional validity time of dedicated priorities (T320) expires; or
- a PLMN selection is performed on request by NAS [5].

NOTE: Equal priorities between RATs are not supported.

The UE shall only perform cell reselection evaluation for E-UTRAN frequencies and inter-RAT frequencies that are given in system information and for which the UE has a priority provided.

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5.2.4.2 Measurement rules for cell re-selection

When evaluating for reselection purposes cell selection criterion or $S_{\text{ServingCell},x}$, the UE shall use parameters provided by the serving cell.

Following rules are used by the UE to limit needed measurements:

- If $S_{\text{intrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{intrasearch}}$, UE may choose to not perform intra-frequency measurements.
- If $S_{\text{ServingCell}} \leq S_{\text{intrasearch}}$, or $S_{\text{intrasearch}}$ is not sent in the serving cell UE shall perform intra-frequency measurements.
- The UE shall apply the following rules for E-UTRAN inter-frequencies and inter-RAT frequencies which are indicated in system information and for which the UE has priority provided as defined in 5.2.4.1:
 - For an E-UTRAN inter-frequency or inter-RAT frequency with a reselection priority higher than the reselection priority of the current E-UTRA frequency the UE shall perform measurements of higher priority E-UTRAN inter-frequency or inter-RAT frequencies according to [10].

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- For an E-UTRAN inter-frequency with an equal or lower reselection priority than the reselection priority of the current E-UTRA frequency and for inter-RAT frequency with lower reselection priority than the reselection priority of the current E-UTRAN frequency:
 - If $S_{\text{nonintrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{nonintrasearch}}$ UE may choose not to perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority.
 - If $S_{\text{ServingCell}} \leq S_{\text{nonintrasearch}}$ or $S_{\text{nonintrasearch}}$ is not sent in the serving cell the UE shall perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority according to [10].

Where $S_{\text{ServingCell}}$ is the S_{rxlev} -value of the serving cell.

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The cell selection criterion S is fulfilled when:

$$S_{rxlev} > 0$$

Where:

$$S_{rxlev} = Q_{rxlevmeas} - (Q_{rxlevmin} + Q_{rxlevminoffset}) - P_{compensation}$$

Where:

the signalled value $Q_{rxlevminOffset}$ is only applied when a cell is evaluated for cell selection as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]. During this periodic search for higher priority PLMN the UE may check the S criteria of a cell using parameter values stored from a different cell of this higher priority PLMN.

S_{rxlev}	Cell Selection RX level value (dB)
$Q_{rxlevmeas}$	Measured cell RX level value (RSRP).
$Q_{rxlevmin}$	Minimum required RX level in the cell (dBm)
$Q_{rxlevminoffset}$	Offset to the signalled $Q_{rxlevmin}$ taken into account in the S_{rxlev} evaluation as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]
$P_{compensation}$	$\max(P_{EMAX} - P_{PowerClass}, 0)$ (dB)
P_{EMAX}	Maximum TX power level an UE may use when transmitting on the uplink in the cell (dBm) defined as P_{EMAX} in [TS 36.101]
$P_{PowerClass}$	Maximum RF output power of the UE (dBm) according to the UE power class as defined in [TS 36.101]

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4.2.2.4 Measurements of inter-frequency E-UTRAN cells

[Editor's note: The RAN2 measurement rules for inter frequency are still to be clarified . It is assumed that the following parameter is defined : $\text{Thresh}_{\text{serv_high}}$: Threshold for the LTE serving cell when the UE initiates measurements, or increases the measurement rate (in the case of high to low priority reselection) on a different E-UTRA frequency layer. This section should be reviewed and updated once more detailed measurement rules are defined by RAN2.]

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the RSRP of the E-UTRA serving cell (or other cells on the same frequency layer) is greater than $\text{Thresh}_{\text{serv_high}}$ then

- the UE may not search for, or measure inter-frequency or inter-RAT layers of equal or lower priority.

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- the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in section 4.2.2. *Editors note: The measurement of cells that are detected in this search is still to be described.*

If the RSRP of the E-UTRA serving cell is less than or equal to $\text{Thresh}_{\text{serv_high},x}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible reselection. In this scenario, the minimum rate at which the UE is required to search for and measure such layers is not reduced.

The UE shall be able to evaluate the need for reselection to a newly detectable inter-frequency cell within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving cells assuming that $T_{\text{reselection}} = 0$. The parameter K_{carrier} is the number of E-UTRA inter-frequency carriers indicated by the serving cell. It shall be possible to evaluate the need for reselection to cells which have:

- $\text{RSRP} \geq -\text{TBD dBm}$ and $\text{Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) \geq [-3] \text{ dB}$.
- $\text{SCH Ior} > -\text{TBD dBm}$ and $\text{SCH Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) > [-3] \text{ dB}$. The UE shall measure RSRP at least every $K_{\text{carrier}} * T_{\text{measure,EUTRAN_Inter}}$ DRX cycle (see table 4.2.2.3-1) for identified inter-frequency cells. If the UE detects on a E-UTRA carrier a cell whose physical identity is indicated as not allowed for that carrier in the measurement control system information of the serving cell, the UE is not required to perform measurements on that cell.

The UE shall filter RSRP measurements of each measured inter-frequency cell using at least [2] measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by at least $[T_{\text{measure,EUTRAN_Inter}}/2]$.

The UE shall not consider a E-UTRA neighbour cell in cell reselection, if it is indicated as not allowed in the measurement control system information of the serving cell.

The filtering shall be such that the UE shall be capable of evaluating that the inter-frequency cell has met reselection criterion defined TS 36.304 within $T_{\text{evaluateFDD,Inter}}$ as specified in table 4.2.2.4-1.

Table 4.2.2.4-1 : $T_{\text{detect,EUTRAN_Inter}}$, $T_{\text{measure,EUTRAN_Inter}}$ and $T_{\text{evaluateFDD,Inter}}$

DRX cycle length [s]	$T_{\text{detect,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{measure,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{evaluateFDD,Inter}}$ [s] (number of DRX cycles)
0.32	[11.52 (36)]	[1.28 (4)]	[5.12 (16)]
0.64	[17.92 (28)]	[1.28 (2)]	[5.12 (8)]
1.28	[32(25)]	[1.28 (1)]	[6.4 (5)]
2.56	[55.88 (23)]	[2.56 (1)]	[7.68 (3)]

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second base station means, located in, and part of, the FDD distributed network, for transmitting, using radio waves, a second BS-packet signal spread signal at a second frequency, with the second frequency different from the first frequency; and

The system utilized by the accused product comprises a second base station (e.g., a cell other than the serving cell of a user equipment), located in, and part of, the FDD distributed network, for transmitting, using radio waves, a second BS-packet signal (e.g., a reference signal) at a second frequency (e.g., inter-frequency cell reselection, a cell operates at different carrier frequency than the serving cell of a user equipment) , with the second frequency different from the first frequency.

4.2.3 E-UTRAN FDD - FDD cell re-selection inter frequency case

4.2.3.1 Test purpose

To verify that when the neighbour cell operates on a different carrier frequency, compared to the current cell the UE is able to search and measure cells to meet the inter-frequency cell re-selection requirements.

4.2.3.2 Test applicability

This test applies to all types of E-UTRA FDD UE release 8 and forward.

4.2.3.3 Minimum conformance requirements

The cell re-selection delay shall be less than $T_{\text{evaluate,E-UTRAN_Inter}} + T_{\text{SI-EUTRA}}$ in RRC_IDLE state.

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is greater than $S_{\text{nonintrasearch}}$ then the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in TS 36.133 [4] clause 4.2.2 as $T_{\text{higher_priority_search}} = (60 * N_{\text{layers}})$ seconds, where the parameter N_{layers} is the total number of configured higher priority E-UTRA carrier frequencies.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is less than or equal to $S_{\text{nonintrasearch}}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible re-selection. In this scenario, the minimum rate at which the UE is required to search for and measure higher priority layers shall be the same as that defined below for lower or equal priority inter-frequency layers.

The UE shall be able to evaluate whether a newly detectable lower or equal priority inter-frequency cell meets the re-selection criteria defined in TS 36.304 [6] within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ (as defined in table 4.2.2.4-1 of TS 36.133 [4] clause 4.2.2.4) if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving

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	<p>The UE shall, if necessary, then register its presence, by means of a NAS registration procedure, in the tracking area of the chosen cell and as outcome of a successful Location Registration the selected PLMN becomes the registered PLMN [5].</p> <p><u>If the UE finds a more suitable cell, according to the cell reselection criteria, it reselects onto that cell and camps on it. If the new cell does not belong to at least one tracking area to which the UE is registered, location registration is performed.</u></p> <p>If necessary, the UE shall search for higher priority PLMNs at regular time intervals as described in [4] and search for a suitable cell if another PLMN has been selected by NAS.</p> <p>Search of available CSGs may be triggered by NAS to support manual CSG selection within the registered PLMN.</p> <p>If the UE loses coverage of the registered PLMN, either a new PLMN is selected automatically (automatic mode), or an indication of which PLMNs are available is given to the user, so that a manual selection can be made (manual mode).</p> <p>Registration is not performed by UEs only capable of services that need no registration.</p> <p>https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf</p>
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	<div>Cell Selection</div>	<p>Control cell selection for example by indicating RAT(s) associated with the selected PLMN to be used initially in the search of a cell in the cell selection. NAS is also maintaining lists of forbidden registration areas and a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) and provide these lists to AS.</p>	<p>Perform measurements needed to support cell selection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Search for a suitable cell. The cells broadcast one or more 'PLMN identity' in the system information. Respond to NAS whether such cell is found or not.</p> <p>If associated RATs is (are) set for the PLMN, perform the search in this (these) RAT(s) and other RATs for that PLMN as specified in [5].</p> <p>If such a cell is found, the cell is selected to camp on.</p>
	<div>Cell Reselection</div>	<p>Control cell reselection by for example, maintaining lists of forbidden registration areas.</p> <p>Maintain a list of equivalent PLMN identities and provide the list to AS.</p> <p>Maintain a list of forbidden registration areas and provide the list to AS.</p> <p>Maintain a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) to camp and provide the list to AS.</p>	<div> <p>Perform measurements needed to support cell reselection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Change cell if a more suitable cell is found.</p> </div>

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suitable cell:

A "suitable cell" is a cell on which the UE may camp on to obtain normal service. Such a cell shall fulfil all the following requirements.

- The cell is part of either:
 - the selected PLMN, or:
 - the registered PLMN, or:
 - a PLMN of the Equivalent PLMN list
- For a CSG cell, the CSG ID broadcast by the cell is present in the allowed CSG list associated with the PLMN for which the above condition is satisfied;

According to the latest information provided by NAS:

- The cell is not barred, see subclause 5.3.1;
- The cell is part of at least one TA that is not part of the list of "forbidden tracking areas for roaming" [4], which belongs to a PLMN that fulfils the first bullet above;
- The cell selection criteria are fulfilled, see subclause 5.2.3.2;

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5.2 Cell selection and reselection

5.2.1 Introduction

UE shall perform measurements for cell selection and reselection purposes as specified in [10].

The NAS can control the RAT(s) in which the cell selection should be performed, for instance by indicating RAT(s) associated with the selected PLMN, and by maintaining a list of forbidden registration area(s) and a list of equivalent PLMNs. The UE shall select a suitable cell based on idle mode measurements and cell selection criteria.

In order to speed up the cell selection process, stored information for several RATs may be available in the UE.

When camped on a cell, the UE shall regularly search for a better cell according to the cell reselection criteria. If a better cell is found, that cell is selected. The change of cell may imply a change of RAT. Details on performance requirements for cell reselection can be found in [10].

The NAS is informed if the cell selection and reselection results in changes in the received system information relevant for NAS.

For normal service, the UE shall camp on a suitable cell, tune to that cell's control channel(s) so that the UE can:

- Receive system information from the PLMN; and
 - receive registration area information from the PLMN, e.g., tracking area information; and
 - receive other AS and NAS Information; and
- if registered:
 - receive paging and notification messages from the PLMN; and
 - initiate transfer to connected mode.

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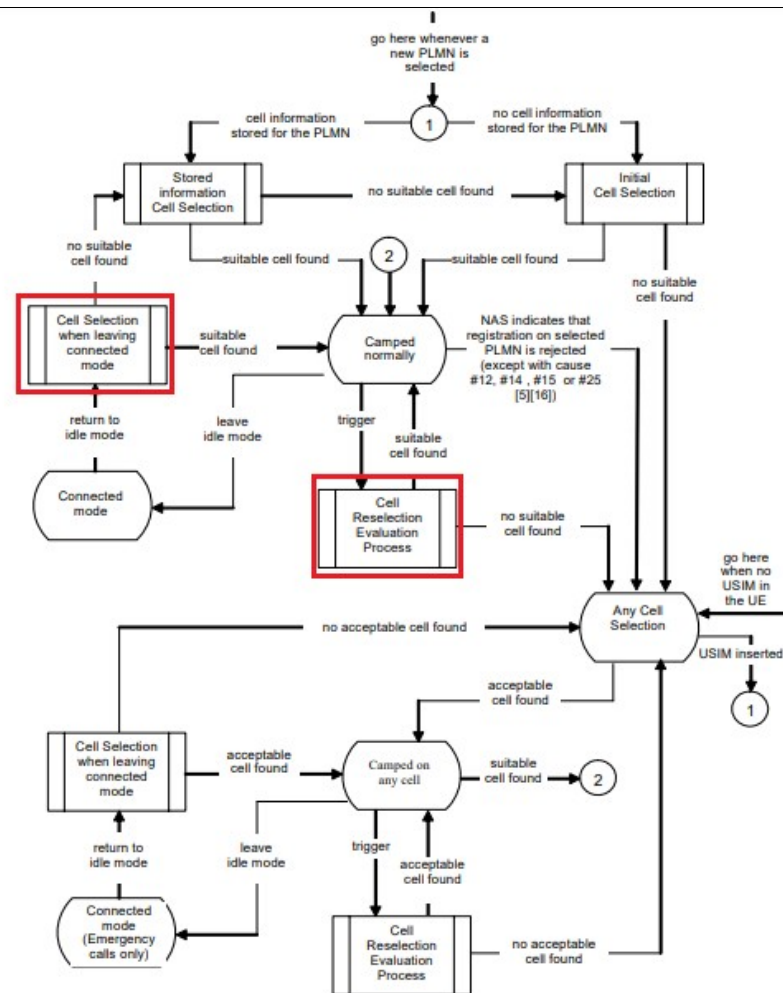


Figure 5.2.2-1: RRC_IDLE Cell Selection and Reselection

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5.2.4.5 E-UTRAN Inter-frequency and inter-RAT Cell Reselection criteria

Criteria 1: the $S_{\text{nonServingCell},x}$ of a cell on evaluated frequency is greater than $\text{Thresh}_{x, \text{high}}$ during a time interval $\text{Treselection}_{\text{RAT}}$;

Cell reselection to a cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- A cell of a higher priority E-UTRAN frequency or inter-RAT frequency fulfils criteria 1; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

Cell reselection to a cell on an equal priority E-UTRAN frequency shall be based on ranking for Intra-frequency cell reselection as defined in sub-clause 5.2.4.6.

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- No cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency fulfills the criteria 1; and
- No cell on serving frequency or on an equal priority E-UTRAN frequency fulfills the criteria in 5.2.4.6; and
- $S_{\text{ServingCell}} < \text{Thresh}_{\text{serving, low}}$ and the $S_{\text{nonServingCell},x}$ of a cell of a lower priority E-UTRAN frequency or inter-RAT frequency is greater than $\text{Thresh}_{x, \text{low}}$ during a time interval $\text{Treselection}_{\text{RAT}}$; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

For GERAN, UTRAN, and E-UTRAN, $S_{\text{nonServingCell},x}$ is the S_{rxlev} -value of an evaluated cell. For UTRAN FDD, S_{qual} is higher than 0, as defined in [8]. For cdma2000 RATs, $S_{\text{nonServingCell},x}$ is equal to $-\text{FLOOR}(-2 \times 10 \times \log_{10} E_c/I_o)$ in units of 0.5 dB, as defined in [18], with E_c/I_o referring to the value measured from the evaluated cell.

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5.2.4 Cell Reselection evaluation process

5.2.4.1 Reselection priorities handling

Absolute priorities of different E-UTRAN frequencies or inter-RAT frequencies may be provided to the UE in the system information, in the *RRCConnectionRelease* message, or by inheriting from another RAT at inter-RAT cell (re)selection. In the case of system information, an E-UTRAN frequency or inter-RAT frequency may be listed without providing a priority (i.e. the field *cellReselectionPriority* is absent for that frequency). If priorities are provided in dedicated signalling, the UE shall ignore all the priorities provided in system information. If UE is in *camped on any cell* state, UE shall only apply the priorities provided by system information from current cell, and the UE preserves priorities provided by dedicated signalling unless specified otherwise. When the UE in *camped normally* state, has only dedicated priorities other than for the current frequency, the UE shall consider the current frequency to be the lowest priority frequency (i.e. lower than the eight network configured values). While the UE is camped on a suitable CSG cell, the UE shall always consider the current frequency to be the highest priority frequency (i.e. higher than the eight network configured values), irrespective of any other priority value allocated to this frequency. The UE shall delete priorities provided by dedicated signalling when:

- the UE enters RRC_CONNECTED state; or
- the optional validity time of dedicated priorities (T320) expires; or
- a PLMN selection is performed on request by NAS [5].

NOTE: Equal priorities between RATs are not supported.

The UE shall only perform cell reselection evaluation for E-UTRAN frequencies and inter-RAT frequencies that are given in system information and for which the UE has a priority provided.

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5.2.4.2 Measurement rules for cell re-selection

When evaluating for reselection purposes cell selection criterion or $S_{\text{ServingCell},x}$, the UE shall use parameters provided by the serving cell.

Following rules are used by the UE to limit needed measurements:

- If $S_{\text{intrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{intrasearch}}$, UE may choose to not perform intra-frequency measurements.
- If $S_{\text{ServingCell}} \leq S_{\text{intrasearch}}$, or $S_{\text{intrasearch}}$ is not sent in the serving cell UE shall perform intra-frequency measurements.
- The UE shall apply the following rules for E-UTRAN inter-frequencies and inter-RAT frequencies which are indicated in system information and for which the UE has priority provided as defined in 5.2.4.1:
 - For an E-UTRAN inter-frequency or inter-RAT frequency with a reselection priority higher than the reselection priority of the current E-UTRA frequency the UE shall perform measurements of higher priority E-UTRAN inter-frequency or inter-RAT frequencies according to [10].

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- For an E-UTRAN inter-frequency with an equal or lower reselection priority than the reselection priority of the current E-UTRA frequency and for inter-RAT frequency with lower reselection priority than the reselection priority of the current E-UTRAN frequency:
 - If $S_{\text{nonintrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{nonintrasearch}}$ UE may choose not to perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority.
 - If $S_{\text{ServingCell}} \leq S_{\text{nonintrasearch}}$ or $S_{\text{nonintrasearch}}$ is not sent in the serving cell the UE shall perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority according to [10].

Where $S_{\text{ServingCell}}$ is the S_{rxlev} -value of the serving cell.

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The cell selection criterion S is fulfilled when:

$$S_{rxlev} > 0$$

Where:

$$S_{rxlev} = Q_{rxlevmeas} - (Q_{rxlevmin} + Q_{rxlevminoffset}) - P_{compensation}$$

Where:

the signalled value $Q_{rxlevminOffset}$ is only applied when a cell is evaluated for cell selection as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]. During this periodic search for higher priority PLMN the UE may check the S criteria of a cell using parameter values stored from a different cell of this higher priority PLMN.

S_{rxlev}	Cell Selection RX level value (dB)
$Q_{rxlevmeas}$	Measured cell RX level value (RSRP).
$Q_{rxlevmin}$	Minimum required RX level in the cell (dBm)
$Q_{rxlevminoffset}$	Offset to the signalled $Q_{rxlevmin}$ taken into account in the S_{rxlev} evaluation as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]
$P_{compensation}$	$\max(P_{EMAX} - P_{PowerClass}, 0)$ (dB)
P_{EMAX}	Maximum TX power level an UE may use when transmitting on the uplink in the cell (dBm) defined as P_{EMAX} in [TS 36.101]
$P_{PowerClass}$	Maximum RF output power of the UE (dBm) according to the UE power class as defined in [TS 36.101]

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4.2.2.4 Measurements of inter-frequency E-UTRAN cells

[Editor's note: The RAN2 measurement rules for inter frequency are still to be clarified . It is assumed that the following parameter is defined : $\text{Thresh}_{\text{serv_high}}$: Threshold for the LTE serving cell when the UE initiates measurements, or increases the measurement rate (in the case of high to low priority reselection) on a different E-UTRA frequency layer. This section should be reviewed and updated once more detailed measurement rules are defined by RAN2.]

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the RSRP of the E-UTRA serving cell (or other cells on the same frequency layer) is greater than $\text{Thresh}_{\text{serv_high}}$ then

- the UE may not search for, or measure inter-frequency or inter-RAT layers of equal or lower priority.

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- the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in section 4.2.2. *Editors note: The measurement of cells that are detected in this search is still to be described.*

If the RSRP of the E-UTRA serving cell is less than or equal to $\text{Thresh}_{\text{serv_high},x}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible reselection. In this scenario, the minimum rate at which the UE is required to search for and measure such layers is not reduced.

The UE shall be able to evaluate the need for reselection to a newly detectable inter-frequency cell within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving cells assuming that $T_{\text{reselection}} = 0$. The parameter K_{carrier} is the number of E-UTRA inter-frequency carriers indicated by the serving cell. It shall be possible to evaluate the need for reselection to cells which have:

- $\text{RSRP} \geq -\text{TBD dBm}$ and $\text{Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) \geq [-3] \text{ dB}$.
- $\text{SCH Ior} > -\text{TBD dBm}$ and $\text{SCH Ior}/(\hat{\text{I}}_{\text{interfering cells}} + \text{Ioc}) > [-3] \text{ dB}$. The UE shall measure RSRP at least every $K_{\text{carrier}} * T_{\text{measure,EUTRAN_Inter}}$ DRX cycle (see table 4.2.2.3-1) for identified inter-frequency cells. If the UE detects on a E-UTRA carrier a cell whose physical identity is indicated as not allowed for that carrier in the measurement control system information of the serving cell, the UE is not required to perform measurements on that cell.

The UE shall filter RSRP measurements of each measured inter-frequency cell using at least [2] measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by at least $[T_{\text{measure,EUTRAN_Inter}}/2]$.

The UE shall not consider a E-UTRA neighbour cell in cell reselection, if it is indicated as not allowed in the measurement control system information of the serving cell.

The filtering shall be such that the UE shall be capable of evaluating that the inter-frequency cell has met reselection criterion defined TS 36.304 within $T_{\text{evaluateFDD,Inter}}$ as specified in table 4.2.2.4-1.

Table 4.2.2.4-1 : $T_{\text{detect,EUTRAN_Inter}}$, $T_{\text{measure,EUTRAN_Inter}}$ and $T_{\text{evaluateFDD,Inter}}$

DRX cycle length [s]	$T_{\text{detect,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{measure,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{evaluateFDD,Inter}}$ [s] (number of DRX cycles)
0.32	[11.52 (36)]	[1.28 (4)]	[5.12 (16)]
0.64	[17.92 (28)]	[1.28 (2)]	[5.12 (8)]
1.28	[32(25)]	[1.28 (1)]	[6.4 (5)]
2.56	[55.88 (23)]	[2.56 (1)]	[7.68 (3)]

https://www.etsi.org/deliver/etsi_ts/136100_136199/136133/08.02.00_60/ts_136133v080200p.pdf

remote station (RS) means for receiving the first BS-packet signal and the second BS-packet signal, and thereby determining a first RS-received signal and a second RS-received signal, respectively; the RS means for monitoring a first signal metric of the first BS-packet signal, RS means for determining that the first signal metric of falls below a threshold, and that the second signal metric is above the threshold, and that the second base station has available capacity, thereby determining to change base stations.

The system utilized by the accused product comprises a remote station (RS) (e.g., the accused product) for receiving the first BS-packet signal (e.g., a first reference signal from the serving cell) and the second BS-packet signal (e.g., a second reference signal from a cell other than the serving cell), and thereby determining a first RS-received signal (e.g., a demodulated signal from a first reference signal received from the serving cell to determine RSRP value for inter-frequency cell reselection) to determine and a second RS-received signal (e.g., a demodulated signal from a second reference signal received from a cell other than the serving cell to determine RSRP value for inter-frequency cell reselection), respectively. The accused product practices determining that a first signal (e.g., a first RSRP value related to a first reference signal) falls below a threshold and that a second signal metric (e.g., a second RSRP value related to a second reference signal) of the second RS-received signal (e.g., a second reference signal received from a cell other than the serving cell) is above the threshold, and that the second base station has available capacity (e.g., the accused product determines that a cell other than the serving cell is suitable cell), thereby deciding to change base stations (e.g., inter-frequency cell reselection).



<https://www.lairdconnect.com/documentation/product-brief-sentrius-rg191lte>

- **LTE CAT 1 M.2 card** – 3GPP Release 11, Bands B2/4/5/12/13 supported – North America Region
- **Full Linux operating system** – Kernel v4.x running on Atmel A5 Core @ 536 MHz
- **Multiple interfaces** such as LTE CAT 1, LoRaWAN, Wi-Fi 802.11a/b/g/n and Ethernet
- **8-Channel LoRaWAN support** with up to +27 dBm max TX power
- **Comprehensive Certifications** for FCC, IC & PTCRB and co-located radio certification
- **Industrial temperature range** (-30° to +70° C)
- **Advanced deployment tools** including intuitive web-based configuration and integrated presets for multiple external LoRa Network Server vendors
- **Enterprise-grade security** built on our years of experience in wireless
- **Industry-leading support** works directly with our engineers to help deploy your design

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<https://www.lairdconnect.com/documentation/product-brief-sentrius-rg191lte>

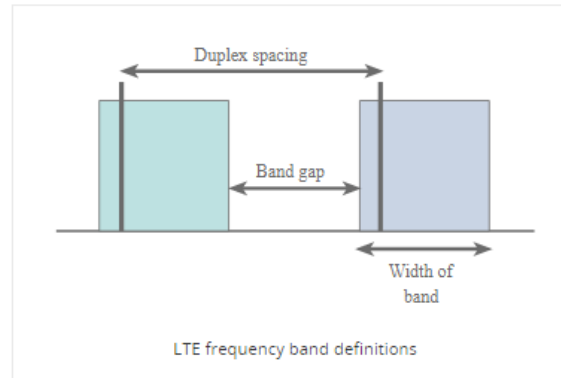
As shown below, the accused product works on LTE frequency band number 2,4,5,12,13 among others. These band numbers correspond to LTE FDD as outlined below.

- **LTE CAT 1 M.2 card** – 3GPP Release 11, Bands B2/4/5/12/13 supported – North America Region
- **Full Linux operating system** – Kernel v4.x running on Atmel A5 Core @ 536 MHz
- **Multiple interfaces** such as LTE CAT 1, LoRaWAN, Wi-Fi 802.11a/b/g/n and Ethernet
- **8-Channel LoRaWAN support** with up to +27 dBm max TX power
- **Comprehensive Certifications** for FCC, IC & PTCRB and co-located radio certification
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- **Enterprise-grade security** built on our years of experience in wireless
- **Industry-leading support** works directly with our engineers to help deploy your design

<https://www.lairdconnect.com/documentation/product-brief-sentrius-rg191lte>

FDD LTE frequency band allocations

There is a large number of allocations or radio spectrum that has been reserved for FDD, frequency division duplex, LTE use.



<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/frequency-bands-channels-spectrum.php>

FDD LTE BANDS & FREQUENCIES					
LTE BAND NUMBER	UPLINK (MHZ)	DOWNLINK (MHZ)	WIDTH OF BAND (MHZ)	DUPLEX SPACING (MHZ)	BAND GAP (MHZ)
1	1920 - 1980	2110 - 2170	60	190	130
2	1850 - 1910	1930 - 1990	60	80	20
3	1710 - 1785	1805 - 1880	75	95	20
4	1710 - 1755	2110 - 2155	45	400	355
5	824 - 849	869 - 894	25	45	20
6	830 - 840	875 - 885	10	35	25
7	2500 - 2570	2620 - 2690	70	120	50
8	880 - 915	925 - 960	35	45	10
9	1749.9 - 1784.9	1844.9 - 1879.9	35	95	60
10	1710 - 1770	2110 - 2170	60	400	340
11	1427.9 - 1452.9	1475.9 - 1500.9	20	48	28
12	698 - 716	728 - 746	18	30	12
13	777 - 787	746 - 756	10	-31	41
14	788 - 798	758 - 768	10	-30	40
15	1900 - 1920	2600 - 2620	20	700	680
16	2010 - 2025	2585 - 2600	15	575	560
17	704 - 716	734 - 746	12	30	18
18	815 - 830	860 - 875	15	45	30
19	830 - 845	875 - 890	15	45	30
20	832 - 862	791 - 821	30	-41	71
21	1447.9 - 1462.9	1495.5 - 1510.9	15	48	33

<https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/frequency-bands-channels-spectrum.php>

4.2.3 E-UTRAN FDD - FDD cell re-selection inter frequency case

4.2.3.1 Test purpose

To verify that when the neighbour cell operates on a different carrier frequency, compared to the current cell the UE is able to search and measure cells to meet the inter-frequency cell re-selection requirements.

4.2.3.2 Test applicability

This test applies to all types of E-UTRA FDD UE release 8 and forward.

4.2.3.3 Minimum conformance requirements

The cell re-selection delay shall be less than $T_{\text{evaluate,E-UTRAN_Inter}} + T_{\text{SI-EUTRA}}$ in RRC_IDLE state.

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is greater than $S_{\text{nonintrasearch}}$ then the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher priority search}}$ where $T_{\text{higher priority search}}$ is described in TS 36.133 [4] clause 4.2.2 as $T_{\text{higher priority search}} = (60 * N_{\text{layers}})$ seconds, where the parameter N_{layers} is the total number of configured higher priority E-UTRA carrier frequencies.

If the $S_{\text{ServingCell}}$ of the E-UTRA serving cell is less than or equal to $S_{\text{nonintrasearch}}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible re-selection. In this scenario, the minimum rate at which the UE is required to search for and measure higher priority layers shall be the same as that defined below for lower or equal priority inter-frequency layers.

The UE shall be able to evaluate whether a newly detectable lower or equal priority inter-frequency cell meets the re-selection criteria defined in TS 36.304 [6] within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ (as defined in table 4.2.2.4-1 of TS 36.133 [4] clause 4.2.2.4) if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving

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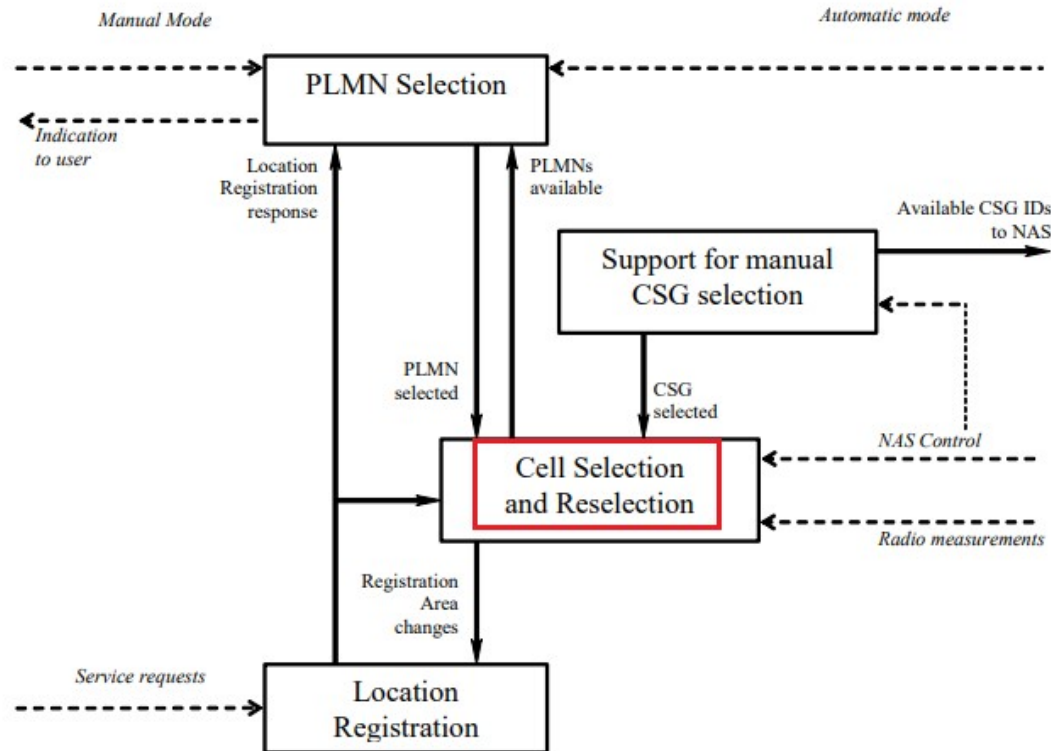


Figure 4.1-1: Overall Idle Mode process

When a UE is switched on, a public land mobile network (PLMN) is selected by NAS. For the selected PLMN, associated RAT(s) may be set [5]. The NAS shall provide a list of equivalent PLMNs, if available, that the AS shall use for cell selection and cell reselection.

With the cell selection, the UE searches for a suitable cell of the selected PLMN and chooses that cell to provide available services, further the UE shall tune to its control channel. This choosing is known as "camping on the cell".

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

	<p>The UE shall, if necessary, then register its presence, by means of a NAS registration procedure, in the tracking area of the chosen cell and as outcome of a successful Location Registration the selected PLMN becomes the registered PLMN [5].</p> <p><u>If the UE finds a more suitable cell, according to the cell reselection criteria, it reselects onto that cell and camps on it. If the new cell does not belong to at least one tracking area to which the UE is registered, location registration is performed.</u></p> <p>If necessary, the UE shall search for higher priority PLMNs at regular time intervals as described in [4] and search for a suitable cell if another PLMN has been selected by NAS.</p> <p>Search of available CSGs may be triggered by NAS to support manual CSG selection within the registered PLMN.</p> <p>If the UE loses coverage of the registered PLMN, either a new PLMN is selected automatically (automatic mode), or an indication of which PLMNs are available is given to the user, so that a manual selection can be made (manual mode).</p> <p>Registration is not performed by UEs only capable of services that need no registration.</p> <p>https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf</p>
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Cell Selection	Control cell selection for example by indicating RAT(s) associated with the selected PLMN to be used initially in the search of a cell in the cell selection. NAS is also maintaining lists of forbidden registration areas and a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) and provide these lists to AS.	<p>Perform measurements needed to support cell selection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Search for a suitable cell. The cells broadcast one or more 'PLMN identity' in the system information. Respond to NAS whether such cell is found or not.</p> <p>If associated RATs is (are) set for the PLMN, perform the search in this (these) RAT(s) and other RATs for that PLMN as specified in [5].</p> <p>If such a cell is found, the cell is selected to camp on.</p>
Cell Reselection	<p>Control cell reselection by for example, maintaining lists of forbidden registration areas.</p> <p>Maintain a list of equivalent PLMN identities and provide the list to AS.</p> <p>Maintain a list of forbidden registration areas and provide the list to AS.</p> <p>Maintain a list of CSG IDs and their associated PLMN ID on which the UE is allowed (Allowed CSG list) to camp and provide the list to AS.</p>	<p>Perform measurements needed to support cell reselection.</p> <p>Detect and synchronise to a broadcast channel. Receive and handle broadcast information. Forward NAS system information to NAS.</p> <p>Change cell if a more suitable cell is found.</p>

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suitable cell:

A "suitable cell" is a cell on which the UE may camp on to obtain normal service. Such a cell shall fulfil all the following requirements.

- The cell is part of either:
 - the selected PLMN, or:
 - the registered PLMN, or:
 - a PLMN of the Equivalent PLMN list
- For a CSG cell, the CSG ID broadcast by the cell is present in the allowed CSG list associated with the PLMN for which the above condition is satisfied;

According to the latest information provided by NAS:

- The cell is not barred, see subclause 5.3.1;
- The cell is part of at least one TA that is not part of the list of "forbidden tracking areas for roaming" [4], which belongs to a PLMN that fulfils the first bullet above;
- The cell selection criteria are fulfilled, see subclause 5.2.3.2;

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5.2 Cell selection and reselection

5.2.1 Introduction

UE shall perform measurements for cell selection and reselection purposes as specified in [10].

The NAS can control the RAT(s) in which the cell selection should be performed, for instance by indicating RAT(s) associated with the selected PLMN, and by maintaining a list of forbidden registration area(s) and a list of equivalent PLMNs. The UE shall select a suitable cell based on idle mode measurements and cell selection criteria.

In order to speed up the cell selection process, stored information for several RATs may be available in the UE.

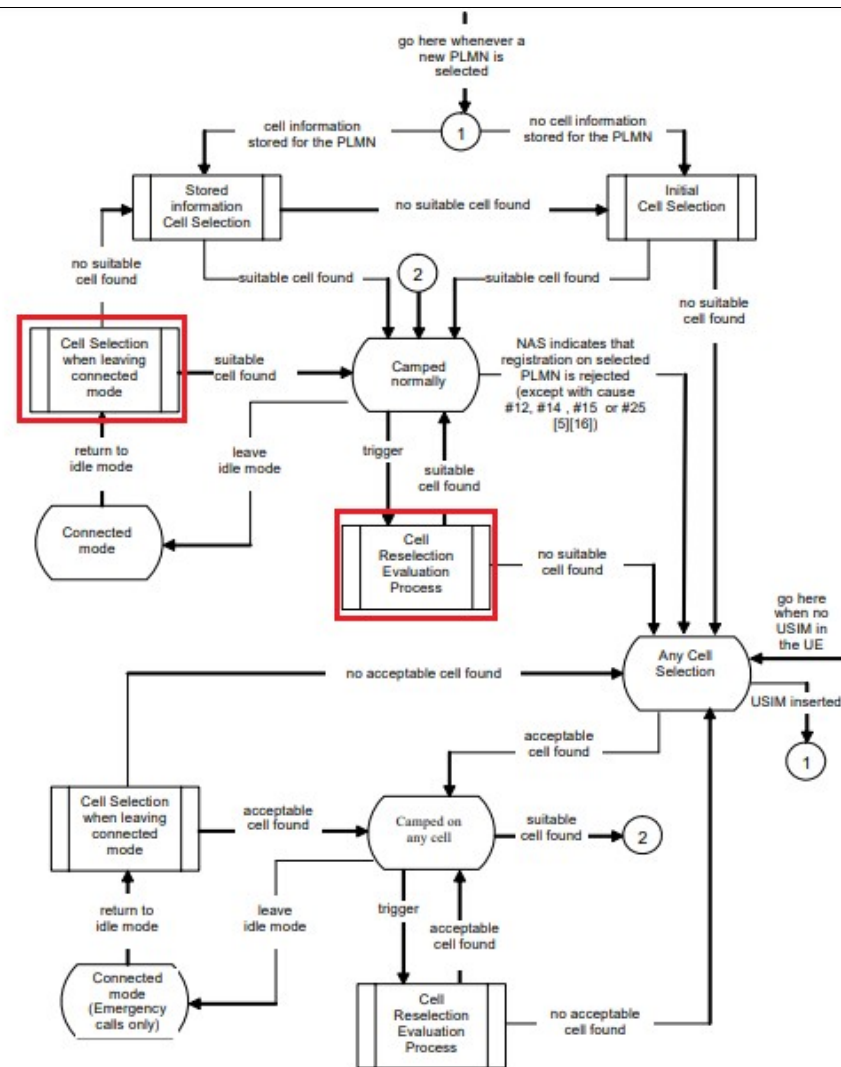
When camped on a cell, the UE shall regularly search for a better cell according to the cell reselection criteria. If a better cell is found, that cell is selected. The change of cell may imply a change of RAT. Details on performance requirements for cell reselection can be found in [10].

The NAS is informed if the cell selection and reselection results in changes in the received system information relevant for NAS.

For normal service, the UE shall camp on a suitable cell, tune to that cell's control channel(s) so that the UE can:

- Receive system information from the PLMN; and
 - receive registration area information from the PLMN, e.g., tracking area information; and
 - receive other AS and NAS Information; and
- if registered:
 - receive paging and notification messages from the PLMN; and
 - initiate transfer to connected mode.

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[ts_136304v081000p.pdf](#)

5.2.4.5 E-UTRAN Inter-frequency and inter-RAT Cell Reselection criteria

Criteria 1: the $S_{\text{nonServingCell},x}$ of a cell on evaluated frequency is greater than $\text{Thresh}_{x, \text{high}}$ during a time interval $\text{Treselection}_{\text{RAT}}$;

Cell reselection to a cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- A cell of a higher priority E-UTRAN frequency or inter-RAT frequency fulfils criteria 1; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

Cell reselection to a cell on an equal priority E-UTRAN frequency shall be based on ranking for Intra-frequency cell reselection as defined in sub-clause 5.2.4.6.

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- No cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency fulfills the criteria 1; and
- No cell on serving frequency or on an equal priority E-UTRAN frequency fulfills the criteria in 5.2.4.6; and
- $S_{\text{ServingCell}} < \text{Thresh}_{\text{serving, low}}$ and the $S_{\text{nonServingCell},x}$ of a cell of a lower priority E-UTRAN frequency or inter-RAT frequency is greater than $\text{Thresh}_{x, \text{low}}$ during a time interval $\text{Treselection}_{\text{RAT}}$; and
- more than 1 second has elapsed since the UE camped on the current serving cell.

For GERAN, UTRAN, and E-UTRAN, $S_{\text{nonServingCell},x}$ is the S_{rxlev} -value of an evaluated cell. For UTRAN FDD, S_{qual} is higher than 0, as defined in [8]. For cdma2000 RATs, $S_{\text{nonServingCell},x}$ is equal to $-\text{FLOOR}(-2 \times 10 \times \log_{10} E_c/I_o)$ in units of 0.5 dB, as defined in [18], with E_c/I_o referring to the value measured from the evaluated cell.

https://www.etsi.org/deliver/etsi_ts/136300_136399/136304/08.10.00_60/ts_136304v081000p.pdf

5.2.4 Cell Reselection evaluation process

5.2.4.1 Reselection priorities handling

Absolute priorities of different E-UTRAN frequencies or inter-RAT frequencies may be provided to the UE in the system information, in the *RRCConnectionRelease* message, or by inheriting from another RAT at inter-RAT cell (re)selection. In the case of system information, an E-UTRAN frequency or inter-RAT frequency may be listed without providing a priority (i.e. the field *cellReselectionPriority* is absent for that frequency). If priorities are provided in dedicated signalling, the UE shall ignore all the priorities provided in system information. If UE is in *camped on any cell* state, UE shall only apply the priorities provided by system information from current cell, and the UE preserves priorities provided by dedicated signalling unless specified otherwise. When the UE in *camped normally* state, has only dedicated priorities other than for the current frequency, the UE shall consider the current frequency to be the lowest priority frequency (i.e. lower than the eight network configured values). While the UE is camped on a suitable CSG cell, the UE shall always consider the current frequency to be the highest priority frequency (i.e. higher than the eight network configured values), irrespective of any other priority value allocated to this frequency. The UE shall delete priorities provided by dedicated signalling when:

- the UE enters RRC_CONNECTED state; or
- the optional validity time of dedicated priorities (T320) expires; or
- a PLMN selection is performed on request by NAS [5].

NOTE: Equal priorities between RATs are not supported.

The UE shall only perform cell reselection evaluation for E-UTRAN frequencies and inter-RAT frequencies that are given in system information and for which the UE has a priority provided.

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5.2.4.2 Measurement rules for cell re-selection

When evaluating for reselection purposes cell selection criterion or $S_{\text{ServingCell},x}$, the UE shall use parameters provided by the serving cell.

Following rules are used by the UE to limit needed measurements:

- If $S_{\text{intrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{intrasearch}}$, UE may choose to not perform intra-frequency measurements.
- If $S_{\text{ServingCell}} \leq S_{\text{intrasearch}}$, or $S_{\text{intrasearch}}$ is not sent in the serving cell UE shall perform intra-frequency measurements.
- The UE shall apply the following rules for E-UTRAN inter-frequencies and inter-RAT frequencies which are indicated in system information and for which the UE has priority provided as defined in 5.2.4.1:
 - For an E-UTRAN inter-frequency or inter-RAT frequency with a reselection priority higher than the reselection priority of the current E-UTRA frequency the UE shall perform measurements of higher priority E-UTRAN inter-frequency or inter-RAT frequencies according to [10].

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- For an E-UTRAN inter-frequency with an equal or lower reselection priority than the reselection priority of the current E-UTRA frequency and for inter-RAT frequency with lower reselection priority than the reselection priority of the current E-UTRAN frequency:
 - If $S_{\text{nonintrasearch}}$ is sent in the serving cell and $S_{\text{ServingCell}} > S_{\text{nonintrasearch}}$ UE may choose not to perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority.
 - If $S_{\text{ServingCell}} \leq S_{\text{nonintrasearch}}$ or $S_{\text{nonintrasearch}}$ is not sent in the serving cell the UE shall perform measurements of E-UTRAN inter-frequencies or inter-RAT frequency cells of equal or lower priority according to [10].

Where $S_{\text{ServingCell}}$ is the S_{rxlev} -value of the serving cell.

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The cell selection criterion S is fulfilled when:

$$S_{rxlev} > 0$$

Where:

$$S_{rxlev} = Q_{rxlevmeas} - (Q_{rxlevmin} + Q_{rxlevminoffset}) - P_{compensation}$$

Where:

the signalled value $Q_{rxlevminOffset}$ is only applied when a cell is evaluated for cell selection as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]. During this periodic search for higher priority PLMN the UE may check the S criteria of a cell using parameter values stored from a different cell of this higher priority PLMN.

S_{rxlev}	Cell Selection RX level value (dB)
$Q_{rxlevmeas}$	Measured cell RX level value (RSRP).
$Q_{rxlevmin}$	Minimum required RX level in the cell (dBm)
$Q_{rxlevminoffset}$	Offset to the signalled $Q_{rxlevmin}$ taken into account in the S_{rxlev} evaluation as a result of a periodic search for a higher priority PLMN while camped normally in a VPLMN [5]
$P_{compensation}$	$\max(P_{EMAX} - P_{PowerClass}, 0)$ (dB)
P_{EMAX}	Maximum TX power level an UE may use when transmitting on the uplink in the cell (dBm) defined as P_{EMAX} in [TS 36.101]
$P_{PowerClass}$	Maximum RF output power of the UE (dBm) according to the UE power class as defined in [TS 36.101]

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4.2.2.4 Measurements of inter-frequency E-UTRAN cells

[Editor's note: The RAN2 measurement rules for inter frequency are still to be clarified . It is assumed that the following parameter is defined : $\text{Thresh}_{\text{serv_high}}$: Threshold for the LTE serving cell when the UE initiates measurements, or increases the measurement rate (in the case of high to low priority reselection) on a different E-UTRA frequency layer. This section should be reviewed and updated once more detailed measurement rules are defined by RAN2.]

The UE shall be able to identify new inter-frequency cells and perform RSRP measurements of identified inter-frequency cells if carrier frequency information is provided by the serving cell, even if no explicit neighbour list with physical layer cell identities is provided.

If the RSRP of the E-UTRA serving cell (or other cells on the same frequency layer) is greater than $\text{Thresh}_{\text{serv_high}}$ then

- the UE may not search for, or measure inter-frequency or inter-RAT layers of equal or lower priority.

https://www.etsi.org/deliver/etsi_ts/136100_136199/136133/08.02.00_60/ts_136133v080200p.pdf

- the UE shall search for inter-frequency layers of higher priority at least every $T_{\text{higher_priority_search}}$ where $T_{\text{higher_priority_search}}$ is described in section 4.2.2. *Editors note: The measurement of cells that are detected in this search is still to be described.*

If the RSRP of the E-UTRA serving cell is less than or equal to $\text{Thresh}_{\text{serv_high},x}$ then the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible reselection. In this scenario, the minimum rate at which the UE is required to search for and measure such layers is not reduced.

The UE shall be able to evaluate the need for reselection to a newly detectable inter-frequency cell within $K_{\text{carrier}} * T_{\text{detect,EUTRAN_Inter}}$ if at least carrier frequency information is provided for inter-frequency neighbour cells by the serving cells assuming that $T_{\text{reselction}} = 0$. The parameter K_{carrier} is the number of E-UTRA inter-frequency carriers indicated by the serving cell. It shall be possible to evaluate the need for reselection to cells which have:

- $\text{RSRP} \geq -\text{TBD dBm}$ and $\text{Ior}/(\hat{I}_{\text{interfering cells}} + \text{Ioc}) \geq [-3] \text{ dB}$,
- $\text{SCH} \hat{\text{Ior}} > -\text{TBD dBm}$ and $\text{SCH} \hat{\text{Ior}}/(\hat{I}_{\text{interfering cells}} + \text{Ioc}) > [-3] \text{ dB}$. The UE shall measure RSRP at least every $K_{\text{carrier}} * T_{\text{measure,EUTRAN_Inter}}$ DRX cycle (see table 4.2.2.3-1) for identified inter-frequency cells. If the UE detects on a E-UTRA carrier a cell whose physical identity is indicated as not allowed for that carrier in the measurement control system information of the serving cell, the UE is not required to perform measurements on that cell.

The UE shall filter RSRP measurements of each measured inter-frequency cell using at least [2] measurements. Within the set of measurements used for the filtering, at least two measurements shall be spaced by at least $[T_{\text{measure,EUTRAN_Inter}}/2]$.

The UE shall not consider a E-UTRA neighbour cell in cell reselection, if it is indicated as not allowed in the measurement control system information of the serving cell.

The filtering shall be such that the UE shall be capable of evaluating that the inter-frequency cell has met reselection criterion defined TS 36.304 within $T_{\text{evaluateFDD,Inter}}$ as specified in table 4.2.2.4-1.

Table 4.2.2.4-1 : $T_{\text{detect,EUTRAN_Inter}}$, $T_{\text{measure,EUTRAN_Inter}}$ and $T_{\text{evaluateFDD,Inter}}$

DRX cycle length [s]	$T_{\text{detect,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{measure,EUTRAN_Inter}}$ [s] (number of DRX cycles)	$T_{\text{evaluateFDD,Inter}}$ [s] (number of DRX cycles)
0.32	[11.52 (36)]	[1.28 (4)]	[5.12 (16)]
0.64	[17.92 (28)]	[1.28 (2)]	[5.12 (8)]
1.28	[32(25)]	[1.28 (1)]	[6.4 (5)]
2.56	[55.88 (23)]	[2.56 (1)]	[7.68 (3)]

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- The UE searches the E-UTRA frequency bands and for each carrier frequency identifies the strongest cell. It reads cell system information broadcast to identify its PLMN(s):
- The UE may search each carrier in turn ('initial cell selection') or make use of stored information to shorten the search ('stored information cell selection').
- The UE seeks to identify a suitable cell; if it is not able to identify a suitable cell it seeks to identify an acceptable cell. When a suitable cell is found or if only an acceptable cell is found it camps on that cell and commence the cell reselection procedure:
- A suitable cell is one for which the measured cell attributes satisfy the cell selection criteria; the cell PLMN is the selected PLMN, registered or an equivalent PLMN; the cell is not barred or reserved and the cell is not part of a tracking area which is in the list of 'forbidden tracking areas for roaming';
- An acceptable cell is one for which the measured cell attributes satisfy the cell selection criteria and the cell is not barred;

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